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Speech production in bilinguals: The role of phonology in Tip-Of-the-Tongue states resolution

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Programa Doutoral em Psicologia
Especialidade de Psicologia Experimental e Ciências Cognitivas

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Speech production in bilinguals: The role of phonology in Tip-Of-the-Tongue states resolution

Abstract

The Tip-Of-the-Tongue (TOT) phenomenon offers an insight into the further comprehension of the architecture and functioning of the speech production system in both monolingual and bilingual populations. In order to study the role of phonology in TOT states induction and resolution, two studies were developed, one considering the performance of European Portuguese (EP) monolinguals and a second study developed with a group of EP-English bilinguals. In both studies, TOT was induced by a picture naming task in which the target words and respective pictures should be carefully characterize in terms of their name agreement, concept familiarity, subjective frequency and visual complexity. Since the norms for these variables were, up to now, unavailable in EP, a previous study was developed that collected these norms for 157 colored and tridimentional pictures. This study enabled us to characterize a dataset that comprises a majority of pictures with relatively high name agreement and low subjective frequency, concept familiarity and visual complexity ratings. These characteristics make the stimuli in the dataset particularly suitable for TOT states induction and resolution experiments. Therefore, based on this EP pictorial database, the two experimental studies on TOT induction and resolution were then developed. In both studies, following each picture, participants had to perform a lexical decision task in which syllabic pseudohomophones related with the target word by the first or the last syllable were embedded in the pseudowords. These methodological options enable us to explore the role of word length (in number of syllables) and syllable position (first vs. last) in TOT induction and resolution in monolinguals and bilinguals. Additionally, in the bilingual study the cognate status (cognate vs. noncognate) of the target words was also considered since previous studies have showed that bilinguals present more TOT states than monolinguals only when considering noncognate words (equivalent translations that share only meaning, e.g, *pepino* [cucumber] in EP and English) but not when considering cognate words (equivalent translations that share form and meaning, e.g., *papel* [paper]) (Gollan & Acenas, 2004).

The two developed studies showed that phonologically related primes (in this case, syllabically) facilitated TOT resolution, even though the role of syllable position is still

controversial. The provided evidence points out to the importance of considering simultaneously the syllable position and the positional syllable frequency in order to clearly determine which segment of the word is more relevant in TOT resolution. Moreover, the word length has determined its relevance in TOT induction particularly when considering a syllable-timed language, for which there were more TOT states in longer than in shorter target words. Finally, in the bilingual study, the word length and the language in use showed to interact with the cognate status of the word in TOT resolution, considering that these words may rely on the structural characteristics of the languages to facilitate word retrieval and TOT resolution.

The forth and last study was developed in order to explore in more detail the cognate word production in EP-French bilinguals by using a different paradigm (a verbal fluency task). Specially, this study allowed to better understand the mechanisms that underlie the differential processing that characterize cognate and noncognate words.

Overall, the present work intended to explore the role of some neglected syllabic variables in the literature (i.e., syllable position and word length) in monolingual and bilingual TOT induction and resolution. Furthermore, it aimed to fully characterize the relevance of the cognate status in bilingual speech production, not only in TOT paradigm but also in a verbal fluency task. Particularly, studying the TOT phenomenon in bilingual speakers contributes to the clarification of what is unique in speech production or what is modulated by the syllabic structure of the languages considered.

Produção linguística em bilingues: O papel da fonologia na resolução de estados Tip-Of-the-Tongue

Resumo

O fenómeno Tip-Of-the-Tongue (TOT) oferece um novo contributo para uma melhor compreensão da arquitectura e funcionamento do sistema de produção linguística tanto em monolingues como em bilingues. De forma a estudar o papel da fonologia na indução e resolução de estados TOT, dois estudos foram desenvolvidos, um considerando a performance de monolingues de Português Europeu (PE) e um segundo estudo desenvolvido com um grupo de bilingues de PE e Inglês. Em ambos os estudos, o TOT foi induzido através de uma tarefa de nomeação de imagens onde as palavras target e respectivas imagens devem ser cautelosamente caracterizadas ao nível da sua concordância de nome, familiaridade conceptual, frequência subjectiva e complexidade visual. Uma vez que as normas para estas variáveis não se encontravam, até à data, disponíveis para o PE, desenvolveu-se um estudo prévio que recolheu estas normas para 157 imagens coloridas e tridimensionais. Este estudo permitiu a caracterização desta base que incluiu uma maioria de imagens com uma concordância de nome relativamente alta e baixa frequência subjectiva, familiaridade conceptual e complexidade visual. Estas características tornam os estímulos desta base particularmente adequados para estudos de indução e resolução de TOT. Assim, baseando-se nas imagens da base de PE, os dois estudos experimentais em indução e resolução de estados TOT foram desenvolvidos. Em ambos os estudos, após a apresentação de cada imagem, os participantes tinham de responder a uma tarefa de decisão lexical na qual pseudohomófonos silábicos relacionados com a palavra target pela primeira ou última sílaba foram incluídos em pseudopalavras. Estas opções metodológicas permitiram explorar o papel da extensão da palavra (em número de sílabas) e a posição silábica (primeira vs. última) na indução e resolução do TOT em monolingues e em bilingues. Adicionalmente, no estudo com bilingues, o estatuto da palavra target (cognata vs. não-cognata) também foi considerado uma vez que estudos anteriores mostraram que os bilingues apresentam mais TOTs que monolingues apenas quando consideradas palavras não-cognatas (traduções equivalentes que apenas partilham significado, e.g., pepino [*cucumber*] em PE e Inglês) mas não quando consideradas palavras cognatas (traduções equivalentes que partilham forma e significado, e.g., papel [*paper*]) (Gollan & Acenas, 2004).

Os dois estudos realizados mostraram que *primes* fonologicamente relacionados (neste caso, silabicamente) facilitaram a resolução de TOT, ainda que o papel da posição silábica seja ainda controverso. A evidência apresentada aponta para a importância de se considerar simultaneamente a posição silábica e a frequência silábica posicional de forma a determinar indubitavelmente que segmento da palavra é mais relevante para a resolução de TOT. Além disso, a extensão da palavra mostrou a sua relevância na indução de TOT particularmente quando considerando uma língua pontuada silabicamente, para a qual houve mais TOTs em palavras longas do que em palavras curtas. Finalmente, no estudo com bilingues, a extensão da palavra e a língua em uso mostraram uma interacção com o estatuto da palavra na resolução do TOT, considerando que palavras cognatas se devem apoiar mais nas características estruturais da língua para facilitar a recuperação da palavra e a resolução do TOT.

O quarto e último estudo foi desenvolvido com o intuito de explorar em mais detalhe a produção de palavras cognatas em bilingues de PE e Francês utilizando um paradigma experimental distinto (i.e., a tarefa de fluência verbal). Em particular, este estudo permitiu perceber melhor os mecanismos que sustentam o processamento diferenciado que caracteriza as palavras cognatas e não-cognatas.

De uma forma geral, o presente trabalho pretendeu explorar o papel de algumas variáveis silábicas geralmente negligenciadas na literatura (i.e., a posição silábica e a extensão da palavra) na indução e resolução de estados TOT em monolingues e bilingues. Além do mais, procurou caracterizar verdadeiramente a relevância do estatuto da palavra na produção linguística bilingue, não só no paradigma de TOT mas também numa tarefa de fluência verbal. Em particular, o estudo do TOT com falantes bilingues contribui para a clarificação do que é único na produção linguística e do que é modulado pela estrutura silábica da língua em estudo.

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INTRODUCTION

"*The state of our consciousness is peculiar. There is a gap therein; but no mere gap. It is a gap that is intensely active. A sort of wraith of the name is in it, beckoning us in a given direction, making us at moments tingle with the sense of our closeness and then letting us sink back without the longed-for term. If wrong names are proposed to us, this singularly definite gap acts immediately so as to negate them. They do not fit the mould. And the gap of one word does not feel like the gap of another, all empty of content as both might seem necessarily to be when described as gaps.*"

William James, Principles of Psychology (1890, p. 251)

The Tip-Of-the-Tongue phenomenon (TOT) is a common experience usually coupled with a strong frustrating feeling caused by the incapability of retrieving a familiar word. The speaker is certain to know the name wanted to recall but in that particular moment he/she is unable to produce it. Even though TOT is considered a low-frequency phenomenon in lab studies (7-19% of induction), it is thought to be a universal experience (Brennen, Vikan, & Dybdahl, 2007; Schwartz, 1999). When in TOT, participants are usually able to retrieve some semantic and syntactic information of the word in TOT (e.g., the shape and function of the object, the word's part-of-speech) and even some phonological information (e.g., the first phoneme, the first syllable or the syllabic stress), though not the entire phonology (e.g., Brown & McNeill, 1966; Burke, Mackay, Worthley, & Wade, 1991; Biedermann, Ruh, Nickels, & Coltheart, 2008; Vigliocco, Antonini, & Garrett, 1997; Vigliocco, Vinson, Martin, & Garrett, 1999). Because the TOT states disclose the different components of speech production (i.e., semantic, synctatic and phonological), its study is a great opportunity to understand the architecture and functioning of the human language production system.

Most studies on TOT states were developed with monolinguals and revealed the existence of two stages in speech production. In a first moment, there is access to the semantic and syntactic components of the word (Brown & McNeill, 1966; Vigliocco et al., 1997), followed by the activation of its phonological and phonetic characteristics (Damian & Martin, 1999). TOTs are assumed to occur due to a problem in the inter-level connection. Specifically, the activation from the lexical to the phonological level seems to be insufficient for all the phonological features to be retrieved (Burke et al., 1991). Therefore, if someone in TOT is confronted with a phonologically related word, the phonological features of this alternative word will increase the activation of the word in TOT, reducing its induction (e.g., James & Burke, 2000), or facilitating its resolution (e.g., Abrams, White, & Eitel, 2003; James & Burke, 2000; Meyer & Bock, 1992; White & Abrams, 2002). Moreover, according to James and Burke (2000), a single phonologically related syllable embedded in an alternative prime word is enough to facilitate TOT resolution. In fact, most influential models of speech production (Dell, 1986; Levelt, Roelofs, & Meyer, 1999) assume the syllable as an important sublexical unit of speech processing. For instance, in Levelt's model (Levelt et al., 1999) speakers have access to the "mental syllabary", a storage of ready-made motor programs for at least the most highly frequent syllables of a given language. Thus, syllabification occurs as a final step of word-form encoding being a late process in lexical access. The presentation of phonological related syllables seems to facilitate the selection of segments that become part of the stored word-form (Cholin, Schiller, & Levelt, 2004), facilitating its production. Since TOT states are usually induced for low-frequency words (e.g., Brown & McNeill, 1966; Burke et al., 1991) and these seem to be more sensitive to syllabic effects than high-frequency words (Jared & Seidenberg, 1990), the effects of phonologically related syllables should be especially relevant in this phenomenon. An interesting but still underexplored question in the literature concerns which segment of the word is more relevant for TOT resolution. For instance, Abrams and collaborators (Abrams et al., 2003; White & Abrams, 2003) stated that presenting the first syllable elicited more TOT resolution than presenting the middle or the last syllable of the word in TOT. However, the way these syllables were presented to the participants is worth considering since some methodological options may compromise the pretended priming effects. In particular, in most studies on phonological priming, the related phonological syllables or phonemes were embedded in words, usually in reading tasks (e.g., Abrams et al., 2003; James & Burke, 2000; White & Abrams, 2002). In fact, Burke et al. (1991) suggested that the use of words as primes could affect the retrieval of the word in TOT because primes and targets could share not only the phonological features but also semantic and syntactic information. Thus, the presentation of syllable priming using pseudowords instead of words or homophones comes as an interesting alternative for the study of TOT resolution. The present research lies within this line of research. In fact, in the studies presented in this work (in monolinguals and in bilinguals), we used syllabic pseudohomophones embedded in pseudowords for TOT states resolution. This also allowed strengthening prime-target phonological links, attenuating orthographic and semantic effects present in homophones or real words.

In line with the role of syllable priming there is another variable that should be explored and that may interfere with the dynamics of lexical access and word retrieval. Namely, it is predictable that the characteristics of the language in use such as the relevance of the syllabic structure or the definition of the syllable boundaries may have a role in lexical access. Up to now, the majority of the studies on TOT states have been developed with English monolinguals. In the present work, the European Portuguese (EP) was the main language explored (first in monolinguals and then in EP-English bilinguals). Compared to English, EP is a syllable-timed language with a regular syllable structure and well defined syllable boundaries, the preferred stress pattern in this language is the penultimate syllable, and the orthography is more transparent than in English (Frota, Vigário, & Martins, 2002). Therefore, it is possible that these differences between languages may lead to different syllabic effects in TOT induction and resolution in EP when compared to English. Furthermore, a language in which the syllable boundaries are well defined increases the interest on exploring other syllabic effects. Particularly, the role of the word length in number of syllables has been underestimated in general speech production research and in TOT states study in particular. Klapp, Anderson, and Berrian (1973) were the first authors to show an effect of the number of syllables in a picture naming task, with participants being slower in producing disyllabic than monosyllabic words. Perry, Ziegler, and

Zorzi (2010) pointed out that, in contrast to monosyllabic words, syllabification strategies and stress assignment must be taken into account when considering longer words. Hence, how word length influences TOT induction and resolution in other languages than English is an interesting question to address. Its study may contribute to a better understanding of the syllabification mechanisms inherent to speech production. These mechanisms should be explicitly implemented in models of speech production and perception, which are up to now, developed taking into consideration mostly monosyllables (Perry et al., 2010; Yap & Balota, 2009).

These models should also consider whether the mechanisms responsible for TOT induction and resolution in monolinguals are widespread to the ones operating in bilinguals. Moreover, the study of bilingual speakers comes as an interesting way to explore the effects of cross-linguistic differences on TOT states. Bilinguals proficiently manage two different languages and the way these languages are organized, stored and accessed can disclose much of the architecture and functioning of the language production and perception systems. In fact, the growth of literature on bilingualism in the last two decades has provided evidence for the universality of cognitive principles and for the constraints of the existing models of speech production and perception. In particular, previous studies have showed that bilinguals present more TOT states than monolinguals (Gollan & Acenas, 2004; Gollan & Silverberg, 2001). This is thought to occur because their connections between levels of speech production are weaker than those of monolinguals, according to the weaker links hypothesis (Gollan & Acenas, 2004). Bilinguals necessarily spend less time using words from each particular language and because the strength of the inter-level connections is mostly dependent on the frequency and recency of use (Burke et al., 1991), their connections will be less activated. Consequently, they are more prone to TOT states than monolinguals. However, Gollan and Acenas (2004) showed that this is true only for noncognate words, i.e., translations that share meaning but no form (e.g., *colchão* in EP and mattress in English). When cognate words are considered (i.e., translations that share form and meaning, e.g., *papel* [paper]) the difference between monolinguals and bilinguals does not emerge. Thus, the shared phonological and orthographic segments of cognate words increase their activation, facilitating their selection and naming (Costa, Caramazza, & Sebastián-Gallés, 2000; Kroll, Dijkstra, Janssen, & Schriefers, 2000) and consequently, reducing TOT induction. However, it is not yet clear in the literature whether in bilinguals the target's cognate status (cognate vs. noncognate) can modulate not only TOT induction but also TOT resolution in line with what happens with phonological priming in monolinguals.

Therefore, the present work presents four different studies. The first study presents a pictorial database created in order to provide the stimuli required for the two following studies that induced TOT through a picture naming task. Then, the two studies on TOT induction and resolution are presented, one developed in monolinguals and other in bilinguals. Finally, a fourth study is presented developed on the scope of a research period of three months at the Laboratoire de Psychologie Cognitive (CNRS and Aix-Marseille Université, France). This last study was also focused on bilingual speech production but on a different production task, the verbal fluency task, with the aim to further explore the performance of bilinguals considering the rate of cognates' production.

Similarly to the most recent TOT research (Gollan & Acenas, 2004; Gollan & Brown, 2006; Gollan, Bonanni, & Montoya, 2005), the two presented studies on TOT induction and resolution induced TOT states through a picture naming task instead of the frequently used definitions (Brown & McNeill, 1966; Choi & Smith, 2005; Gollan & Silverberg, 2001). Using definitions might inhibit TOT induction and/or facilitate TOT resolution by activating semantic or syntactic information inadvertently present in the definition (Facal-Mayo, Juncos-Rabadán, Álvarez, Pereiro-Rozas, & Díaz, 2006). Hence, using pictures seems to be a more reliable way to induce TOT states and to confirm the role of phonology in a more controllable research setting. Consequently, the selection of proper stimuli is crucial for the development of cautious and controlled research in cognitive and experimental psychology in general, but most specifically in TOT studies. Therefore, the first study was developed focusing on the pictorial stimuli used on the two subsequent studies on TOT states. For a proper TOT induction, the pictorial stimuli selected needed to be carefully controlled, based on a language-specific standardization process that took into consideration specific characteristics and attributes of the pictures used. Namely, in this first study, the norms for name agreement, subjective frequency, concept familiarity and visual complexity for 157 colored and tridimensional pictures in EP are presented. These characteristics have been showed to be critical for naming latencies and memory processes, particularly in name retrieval and lexical access (Alario et al., 2004; Cycowicz, Friedman, Rothstein, & Snodgrass, 1997; Rossion & Pourtois, 2004; Sanfeliu & Fernandez, 1996) and were up to now absent for EP. This database constitutes an important tool for future research studies in cognitive psychology, as it allows for a cautious selection of pictorial stimuli based in some of the most relevant variables in cognitive literature.

Subsequently, the two studies on TOT induction and resolution are presented. First, the study with EP monolinguals was developed with the aim to explore the role of syllable position (first vs. last) and number of syllables (two, three, and four) in EP, a language with well-defined syllable boundaries. Following, the TOT study developed with EP-English bilinguals attempts to provide additional evidence not only on the role of cognate status (cognate vs. noncognate) but also on the syllable position (first vs. last) and word length (two vs. three syllables). This study allowed analyzing the communalities and dissimilarities on the mechanisms responsible for TOT induction and resolution in monolinguals and in bilinguals. As mentioned, in both studies an innovative methodology was developed in order to provide phonological priming in a more implicit way to the participants in TOT. TOTs were induced using a picture naming task, after which a lexical decision task was presented. Here, the first and the last syllable of the target word (e.g., *pincel* [paintbrush]) were embedded in pseudowords (e.g., for the target word *pincel* [paintbrush], *pintro* and *pimpota* were primes related by the first syllable and *crissel* and *tranecel* related by the last syllable). These syllabic pseudohomophones differed in orthography but maintained the original phonology of the target's syllable. Using syllabic pseudohomophones embedded in pseudowords diminished the activation of orthographic and/or phonological neighbours that could interfere in word retrieval (e.g., see Ferrand & Grainger, 1994; Ferrand, Segui, & Grainger, 1996). Moreover, it allowed reinforcing the prime-target phonological links, attenuating orthographic and semantic effects.

Finally, the fourth study presented was focused on bilingual speech production in a verbal fluency task. Even though this study is focused on a different production task, it was developed in line with the bilingual TOT study, with the aim to further explore the performance of bilinguals considering the rate of cognates' production. In a verbal fluency task participants are asked to produce a maximal number of words of a certain category (i.e., semantic - e.g., animals - or letter - e.g., words starting with the letter F) during a determined amount of time (usually one minute; Roberts & Le Dorze, 1997). Similarly to what is found in TOT research, previous studies on this task also reported differences in the naming performance between monolingual and bilingual speakers (e.g., Gollan, Montoya, & Werner, 2002; Gollan, Montoya, Cera, & Sandoval, 2008; Rosselli et al., 2000; Sandoval, Gollan, Ferreira, & Salmon, 2010). Bilinguals seem to produce a lower number of exemplars than monolinguals especially for semantic categories. It was thought that the difference between semantic and letter categories may be related with the amount of cognate words that bilinguals are able to produce in each type of category (see Michael & Gollan, 2005). In fact, bilinguals seem to produce more cognate words in letter than in semantic categories (Sandoval et al., 2010). Therefore, when bilinguals are able to produce more cognates, they produce more exemplars and consequently, get closer to the monolinguals performance in the total amount of exemplars produced. Moreover, not only the type of category but also the time-restriction imposed by the task settings may constraint the amount of exemplars produced by a bilingual. Thus, in this study a group of EP-French bilinguals was asked to respond to two different (typing) verbal fluency tasks. The first task is a more standard verbal fluency task, in which participants were asked to respond to three semantic and three letter categories. Here, the time period for the participants to respond was increased (i.e., five minutes instead of the standard

60 seconds) which allowed testing the retrieval of more difficult words, providing a better description of cognate retrieval over time. In the second task, participants were asked to generate one single exemplar that simultaneously belonged to a semantic and letter category. An estimation of the maximum number of cognates that could be generated in the used semantic categories was calculated previously to control for a priori unequal proportions of cognates per category. For that purpose, nine out of the 21 semantic categories presented in the French database Basety (Léger, Boumlak, & Tijus, 2008) were translated. The phonetic transcriptions in both languages were compared and a word was considered to be a cognate if it needed less than three substitutions to edit one string into its equivalent translation (considering insertions and deletions). Thus, this study allowed exploring the relevant role of cognate status on bilingual speech production in a distinct paradigm including some methodological options that allowed a better control on cognate production. This study was an opportunity to explore in more detail how the cognate status affects bilingual performance in speech production.

To summarize, the present work aimed to explore the role of some neglected variables in literature (syllable position and word length) in monolingual and bilingual TOT induction and resolution as well as to fully characterize how cognate words are processed in bilingual populations. The results enabled us to understand the organization of the language production system, the links between its levels of activation and its general functioning. Particularly, studying the TOT phenomenon in bilingual speakers allowed understanding not only the common mechanisms across bilinguals and monolinguals but also the distinctiveness of the bilingual production system.

EXPERIMENTAL STUDIES

Portuguese norms of name agreement, concept familiarity, subjective frequency and visual complexity for 157 pictures[1]

Abstract

The selection of proper stimuli is crucial for the development of cautious and controlled research in cognitive and experimental psychology. The use of pictorial stimuli in research has expanded in the last decades. This type of stimuli requires a careful, language-specific standardization process that takes into consideration characteristics and attributes of the pictures used. These characteristics are critical for naming latencies and memory processes, particularly in name retrieval and lexical access within Tip-Of-the-Tongue (TOT) studies.

The present work is the first European Portuguese (EP) study to offer norms for name agreement, subjective frequency, concept familiarity and visual complexity for 157 colored and tridimensional pictures. A total of 640 EP native speakers participated in this study through a web survey, answering to 50 randomly selected pictures from the 157 pictures in the dataset.

Results showed that the present dataset comprises a majority of pictures with high name agreement and low subjective frequency, concept familiarity and visual complexity ratings. Normative ratings are similar to the ones obtained in previous studies although the pictures are different. Therefore, this seems to be an important tool for the design of future research studies in cognitive psychology, as it allows for a cautious and pondered selection of pictorial stimuli in EP and considers some of the most explored measures in the literature.

Experimental research in perception, memory or language has often used pictures as stimuli to explore different cognitive processes such as object processing, lexical access or language production. Although they were initially used in studies on perceptual identification and recognition (Snodgrass, 1984; Snodgrass & Poster, 1992), and on comparisons between word and picture processing speed (Lotto, Rumiani, & Job, 1996), the use of pictures has expanded to different fields of research in cognitive psychology. For instance, in language studies, pictures are often used in Tip-Of-the-Tongue (TOT) induction and resolution to overcome methodological limitations of the definitions used traditionally. Specifically, the definitions employed in TOT induction might contain semantic or syntactic information about the word in TOT, which can inadvertently bias the results. Therefore, the use of pictorial stimuli seems to be a more efficient and controlled methodological option in the study of TOT

[1] Paper submitted to Behavior Research Methods

states (see Gollan & Acenas, 2004; Gollan, Bonanni, & Montoya, 2005; Pureza, Soares, & Comesaña, 2013, for more detail).

Although the use of pictures has expanded, and despite their methodological advantages, pictures contain characteristics and attributes that seem to have an effect on naming latencies and memory processes, particularly in name retrieval and lexical access (e.g., Alario et al, 2004; Cycowicz, Friedman, Rothstein, & Snodgrass, 1997; Rossion & Pourtois, 2004; Sanfeliu & Fernandez, 1996). For instance, it has been shown that pictures representing a high-frequency object are named faster than pictures representing a low-frequency object. The same effect is observed for pictures with low visual complexity, high familiarity, or high name agreement (e.g., Alario et al, 2004; Cycowicz et al., 1997). Therefore, for picture selection researchers should consider these important attributes for control and/or manipulation of the characteristics of the stimuli in psychological and neuropsychological cognitive research studies.

Normative data for pictorial stimuli started to gain ground after the seminal work by Snodgrass and Vanderwart in 1980. This work presents a set of 260 pictures (black and white line drawings) and their corresponding norms for name agreement, image agreement, familiarity and visual complexity. Snodgrass and Yuditsky (1996) presented the naming latencies for each of the pictures in the original set and showed age of acquisition and name agreement as the best predictors of naming latencies. Many databases for different languages have been developed since then (e.g., British English: Barry, Morrison, & Ellis, 1997; Vitkovitch & Tyrrell, 1995; Chinese: Weekes, Shu, Hao, Liu, & Tan, 2007; French: Alario & Ferrand, 1999; Bonin, Peereman, Malardier, Méot, & Chalard, 2003; Greek: Dimitropoulou, Duñabeitia, Blitsas, & Carreiras, 2009; Icelandic: Pind, Jónsdóttir, Gissurardóttir, & Jónsson, 2000; Italian: Dell'Acqua, Lotto, & Job, 2000; Japanese: Nishimoto, Miyawaki, Ueda, Une, & Takahashi, 2005; Russian: Tsaparina, Bonin, & Méot, 2011; and Spanish: Cuetos, Ellis, & Álvarez, 1999; Sanfeliu & Fernandez, 1996). The emergence of these databases in different languages is not surprising since cultural and linguistic differences seem to affect picture classification, identification and naming (Tsaparina et al., 2011; see also Dimitropoulou et al., 2009, and Yoon et al., 2004). However, their existence in European Portuguese (EP) is scarce.

In EP psychological and neuropsychological cognitive research, stimuli are usually selected and characterized for each specific study thus resulting in little stimuli homogeneity across studies. To the best of our knowledge, one single study was published with picture norms for EP (Ventura, 2003). The author selected 219 pictures from the original black and white line drawings used by Snodgrass and Vanderwart (1980) and collected norms for familiarity (i.e., degree according to which the participant gets in contact or thinks about the concept), value assigned to the item (i.e., the importance of the object in the participant's daily life), visual ambiguity (i.e., estimation of the number of things that are visually similar to the item), age of acquisition (i.e., estimation of the age with which the participant has learned the item and its name for the first time), size (i.e., estimation of the real size of the object depicted), level of manipulation (i.e., extent to which the use of hands is needed for the object to fulfill its function) and characteristic movement (i.e., estimate on whether there is a typical movement of the object). Even though the EP norms provided by Ventura are a useful tool for Portuguese researchers, this study does not provide the norms for name agreement, image agreement or visual complexity presented in the original work of Snodgrass and Vanderwart (1980), assumed as the most important dimensions to be controlled for or manipulated in cognitive and neuroscientific research with pictorial stimuli.

Hence, the aim of the present study was to collect EP norms for name agreement, concept familiarity, subjective frequency and visual complexity for 157 colored pictures. Given that the ultimate purpose of this work was to obtain pictorial stimuli that could increase the probability to induce TOT states in an artificial context in EP, the adaptation of previous datasets could not fulfill our requirements in terms of the pictorial and lexical properties of the stimuli. Additionally, the option to select colored pictures instead of black and white drawings as used by Snodgrass and Vanderwart (1980) was due to the fact that recent studies have shown that color plays an important role in the improvement of naming accuracy and naming speed (Dimitripoulou et al., 2009; Rossion & Pourtois, 2004; Tsaparina et al., 2011). Because color information is an integral part of object representation it facilitates recognition in normal daily conditions (Rossion & Pourtois, 2004). Therefore, participants should easily recognize colored pictures of real tridimensional objects since they are closer to the real objects that they recognize and name on a daily basis in their natural environment. Thus, with this purpose in mind, a new set was created to fulfill the requirements of future research in cognitive psychology, particularly in language production and recognition in EP. A total of 157 tridimensional and colored pictures was selected to collect norms for the most generally used dimensions in research, particularly name agreement, concept familiarity, subjective frequency and visual complexity.

Name agreement (NA), as originally defined by Snodgrass and Vanderwart (1980) refers to the number of different designations given to a particular picture across participants or the proportion of participants that assign the same name to a given object (Snodgrass & Vanderwart, 1980). It is one of the most studied dimensions affecting picture naming and recognition. There are two measures of NA, namely the percentage of subjects producing the most common name (i.e., modal name), and the *H*-statistic (Snodgrass & Vanderwart, 1980) that assesses the dispersion of the responses provided (valued zero if all participants provide the same name for the picture, and an increasing value as the number of different responses increases). The *H*-statistic is computed by the following formula:

$$H=\sum_{i=1}^{k} P_i \, log_2(1/P_i)$$

where *k* refers to the number of possible answers given and P_i to the proportion of participants who assigned each name (Snodgrass and Vanderwart, 1980, for more detail).

The *H* measure, widely used in literature (e.g. Alario & Ferrand, 1999; Bonin et al., 2003; Dimitropoulou et al., 2009; Rossion & Pourtois, 2004), is thought to be more informative than the straightforward percentage because it considers the dispersion and distribution of responses provided for each picture. The effect of NA on picture naming has been well established, revealing that pictures with higher levels of NA (i.e., lower number of alternative names) are named faster than pictures of low NA (e.g., Alario et al., 2004; Barry et al., 1997; Snodgrass & Yuditsky, 1996; Vitkovitch & Tyrrell, 1995). It is not surprising that this variable has been considered one of the strongest predictors of picture naming latencies (e.g., Alario et al., 2004; Liu, Hao, Li, & Shu, 2011; Ferrand, 1999). NA also shows strong correlations with meaningfulness and familiarity (e.g., Mcdougall, Curry, & de Bruijn, 1999).

The conceptual familiarity of the objects is another key variable that has been shown to affect performance in experimental tasks using pictorial stimuli, particularly in picture naming and semantic processing (e.g., Cuetos et al., 1999; Dell'Acqua et al., 2000; Schröder, Gemballa, Ruppin, & Wartenburger, 2012). This variable is related to the frequency with which the objects depicted are encountered or the frequency of its occurrence in daily life (Snodgrass & Vanderwart, 1980). It is sometimes referred to as subjective frequency although both variables should be considered independently (Balota, Pilotti, & Cortese, 2001). According to Balota and colleagues, familiarity and subjective frequency are usually semantically confounded and therefore it seems crucial to cautiously partial out the variable to be evaluated in order to capture its particular effect. Participants seem to be more prone to rely on semantic properties than on frequency of exposure estimates when asked to evaluate the familiarity of an object, which seems to be the key factor to disentangle both concepts. According to Hirsh and Funnell (1995), conceptual familiarity has the same function for pictures as frequency has for words – the more familiar a concept is, the shorter the naming latencies for that item will be. This measure seems relevant for perceptual identification and recognition, with familiar items being identified and recognized more accurately than low-familiarity concepts (Cuetos et al., 1999; Kroll & Potter, 1984; Snodgrass & Poster, 1992).

Subjective frequency is the estimation of the frequency with which subjects use a word (in written or spoken modality) to designate a certain picture. It is considered one of the most effective predictors of picture naming latencies (Dimitropoulou et al., 2009; Snodgrass & Yuditsky, 1996), that highly correlates with objective frequency measures (see Balota, et al., 2001; Desrochers & Thompson, 2009). Thus, pictures named by high-frequency words are responded to faster and more accurately than pictures named by low-frequency words (e.g., Dimitropoulou et al., 2009; Humphreys, Riddoch, & Quinlan, 1988; Snodgrass & Yuditsky, 1996).

Finally, visual complexity has to do with the number of lines, details and elements in the picture (Attneave, 1957; Ellis & Morrison, 1998). This variable should be considered for pictorial stimuli because of its influence on object identification and, to a lesser extent, on naming (more complex items tend to be identified more slowly and less accurately than simpler ones - Alario et al., 2004; Mcdougall et al., 1999). It is closely correlated with concreteness, since the more concrete a picture is, the more complex it tends to be (Mcdougall et al., 1999). In fact, García, Badre, and Stasko (1994) showed that concrete symbols contained more details than abstract symbols.

To sum up, the present work aims at collecting normative values for name agreement, concept familiarity, subjective frequency and visual complexity for 157 colored and tridimensional pictures. It is, to the best of our knowledge, the first colorized dataset study in EP to collect these measures. In addition, this dataset also presents norms for lexical word frequency (per million occurrences), number of orthographic syllables and number of letters of the modal names of each picture taken from the P-PAL database (Soares et al., in press; available at http://p-pal.di.uminho.pt/tools/menu). Likewise, the number of *Know*, *Don't Know* and *Don't Remember* (indication of a possible TOT state) answers for each picture is also provided, which can be of particular relevance for researchers focused on TOT states induction and resolution.

Experiment

Method

Participants

A total of 640 EP native speakers participated in this study (428 females; M_{age} = 24.6, *SD* = 6.98). All participants were volunteer university students from different Portuguese institutions who did not receive any compensation for their participation in the study.

Materials

The 157 pictures of colorized and tridimensional objects or animals that constitute this dataset were selected from public picture databases such as Google Images (www.google.com/imghp). All pictures had an approximate size of 580 pixels of length with variable width and a resolution of 36.00 pixels/cm. The pictures were colored and presented on a white background. In two cases (picture 32. *vinagre* [vinegar] and 69. *pilão* [pestle]) an arrow was added in order to specify the object to be named. Ten modal names in the dataset could intentionally be depicted by two different pictures with the purpose of allowing researchers to select the picture that best fit a certain lexical label - *bazuca* [bazooka] (numbers 3 and 17); *ramo-de-flores* [bouquet] (numbers 8 and 10); *catedral* [cathedral] (numbers 28 and 30); *iguana* [iguana] (numbers 43 and 45); *seringa* [syringe] (numbers 31 and 35); *nabo* [turnip] (numbers 49 and 93); *procissão* [procession] (numbers 57 and 58); *pepino* [cucumber] (numbers 101 and 121); *pedal* [pedal] (numbers 72 and 91); and *melão* [melon] (numbers 25 and 106). The overall set was distributed into 18 semantic categories: accessories (7 pictures); animals (27 pictures); buildings (3 pictures); clothes (4 pictures); fantasy (4 pictures); flowers (5 pictures); food (6 pictures); fruits and vegetables (20 pictures); furniture (18 pictures); games (5 pictures); music (4 pictures); nature (4 pictures); personal traits (2 pictures); professions (3 pictures); religion (2 pictures); tools (31 pictures); transports (6 pictures); weapons (6 pictures).

Procedure

For the purpose of the present study a web site was created to collect norms for name agreement, concept familiarity, subjective frequency and visual complexity. Web surveys have been increasingly used in research due to their advantages, particularly in terms of cost and access to a large sample of participants (see Soares et al., 2012, for a recent example). The hyperlink was distributed via email and sent to the addresses of students who were attending different degrees at Portuguese universities.

At the beginning of the task participants were asked to fill in a form with their demographic information, specifically their name, age, gender, nationality, native language and level of education. Instructions on how to assess each attribute for each picture were then carefully detailed as follows: for each picture participants were asked to indicate if they knew, did not know or did not remember (indicative of a possible TOT state answer, as mentioned) the name of the object presented. Participants who reported knowing the name were asked to fill in the provided blank space with the corresponding name followed by their own estimates on the frequency, concept familiarity and visual complexity of each particular stimulus. To assess the subjective frequency of the name of each picture, participants should consider how frequently they used a particular concept on a daily basis using a 5-point Lickert scale where 1 corresponds to "very low frequency use" and 5 to "very high frequency use". In order to assess the degree according to which one comes in contact with or thinks about a concept (concept familiarity), participants answered on a 5-point Lickert scale, with 1 corresponding to "very unfamiliar concept" and 5 to "very familiar concept". Finally, participants were asked to assess the visual complexity of each picture, considering the number of details and intricacy of the lines in the picture, also on a 5-point Lickert scale ranging from 1 (very simple picture) to 5 (very complex picture). After assessment of all the parameters for a given picture, a new stimulus was presented. Participants were encouraged to answer as quickly as possible but to provide careful and honest responses while trying not to make mistakes. In order to avoid fatigue, each participant assessed a set of 50 pictures drawn randomly from the entire dataset. Each picture was presented at the center of the screen until participants provided a complete response to all variables. The task lasted approximately 10 to 15 minutes.

Results and Discussion

Normative values of the EP dataset presented in this paper can be downloaded at http://p-pal.di.uminho.pt/about/databases. The dataset is organized according to the number of the picture (i.e., from 1 to 157), which matches its NA value (*H*), i.e., picture 1 represents the lower name agreement value in the dataset and picture 157 the higher name agreement value. For each picture, the following information is provided, starting from the leftmost column: (1) number of the picture (Picture Number); (2) modal name given in EP and its translation equivalent in English (Modal name); (3) percentage of *Know* answers (Know); (4) percentage of *Don't Know* answers (DK); (5) percentage of *Don't Remember* answers (DR); (6) *H*-statistic for NA (NA_H); (7) NA score measured by the percentage of participants giving the modal name (NA_%); (8) subjective frequency ratings (SubjFreq. - mean and standard deviation); (9) concept familiarity ratings (Fam. – mean and standard deviation); (10) visual complexity ratings (VC – mean and standard deviation); (11) number of alternative answers given to same picture (Different answers); (12) number of letters (letters); (13) number of syllables (syllables); (14) per million objective word frequency values (Freq. P_Pal) (the last three psycholinguistic measures were obtained, as stated above, from the P-PAL database - Soares et al., in press); and (14) Semantic Category.

The norms are based on a total of 19,015 responses. Each participant assessed 50 out of the total 157 pictures in the dataset, thus the average number of answers for each picture was 121.11 (*SD*

= 57.24) with a minimum of 88 and a maximum of 338 answers. From the total number of responses, 87.4% were *Know* answers (even though each picture can originate several possible designations, i.e., it can have a variable NA value), 4.5% were *Don't Know* answers, and 8.1% were *Don't Remember* answers (possibly indicative of a TOT state). It is worth noting that from the total set, 16 pictures did not yield *Don't Know* or *Don't Remember* answers (e.g., 18. *monitor* [monitor]; 62. *revólver* [revolver]; 96. *canela* [cinnamon]), i.e., all generated Know answers followed by valid picture naming. However, only nine of these presented one single model name without any other possible description of the object, i.e., all participants agreed on the same name for those pictures, presenting an *H* value of 0.00 (namely from 149. *balão* [balloon] to 157. *zebra* [zebra]).

Table 1 contains the summary statistics for name agreement, subjective frequency, concept familiarity and visual complexity as well as the average percentage of *Know*, *Don't Know* and *Don't Remember* answers (mean, standard deviation, range, minimum, maximum, median, quartile values (Q1 and Q3) and skewness).

Table 1

Summary Statistics for Name Agreement (H-statistic and %), Subjective Frequency, Concept Familiarity, Visual Complexity, and percentage of Know, Don't Know and Don't Remember answers

	Mean	SD	Range	Min	Max	Median	Q1	Q3	Skew
H	1.09	0.90	4.41	0.00	4.41	1.00	.34	1.62	.92
%	75.05	22.53	83	17	100	80	58	95	.69
Subj. Freq.	2.69	.86	3.49	1.17	4.66	2.56	2.02	3.37	.51
Fam.	3.27	.73	2.99	1.73	4.72	3.19	2.70	3.85	.10
VC	2.52	.60	2.85	1.36	4.21	2.45	2.04	2.94	.32
Know	87.51	16.68	82.57	17.73	100.00	94.22	84.66	98.05	-2.13
Don't Know	4.54	9.22	62.86	0.00	62.86	1.52	0.00	4.73	4.19
Don't Remember	7.94	9.99	52.75	0.00	52.75	4.00	1.02	11.65	1.92

Note. Subj. Freq. = Subjective Frequency; Fam. = Concept Familiarity; and VC = Visual Complexity were rated on a 5-point Lickert scale. Q1 = 25th percentile; Q3 = 75th percentile; skew (>1 is positively skewed).

Table 1 shows that the mean value of *H*-statistic (*M* = 1.09) is higher than the values obtained in previous works (0.29 in Alario et al., 2004; 0.36 in Alario & Ferrand, 1999; 0.67 in Bonin et al., 2003; and 0.56 in Snodgrass & Vanderwart, 1980). This indicates that the pictures in the present dataset have a higher level of dispersion of possible designations for each picture (*Median* = 1.00; *Q3* = 1.62). Indeed, only 23 pictures in this dataset presented a score of 100% of NA (i.e., $H = 0$) (namely from 135. *manga* [mango] to 157. *zebra* [zebra]). Furthermore, 110 pictures had a NA score above 50% (e.g., 70. *couve* [cabbage]) and 24 pictures had percentages of NA below 50% (e.g., 3. *bazuca* [bazooka]). The *H*-statistic scores ranged from 0.00 (only one answer provided – e.g., 136. coala [koala]) to 4.41 (picture 1. *fada* [fairy] presented 35 possible designations).

The NA ratings obtained were expected considering that the present pictorial database was built initially with the purpose of selecting stimuli for a TOT states induction research, where low-frequency words are typically used (Burke, Mackay, Worthley, & Wade, 1991; Pureza et al., 2013). Results are therefore in line with the established outcome that pictures rated as low frequent tend to be named less accurately than high-frequency pictures (Humphreys et al., 1988). In fact, 65% of the 157 pictures were rated as low frequency (between 1.17 and 3.00). The subjective frequency median is 2.56 and its distribution is negatively skewed (*skew* = .51). Due to these particular features, the pictorial stimuli present in this dataset can be especially relevant for TOT states induction and resolution.

Concerning concept familiarity ratings, the range obtained was 2.99, with a minimum of 1.73 (e.g., 39. *tiara* [tiara]) and a maximum of 4.72 (e.g., 15. *televisão* [television]). These ratings are very close to the ones obtained by Snodgrass and Vanderwart (1980), and slightly higher than the ones obtained, for example, by Alario et al. (2004), Alario and Ferrand (1999) or Bonin et al. (2003).

Norms for visual complexity ranged from 1.36 (e.g., 27. *pêndulo* [pendulum]) to 4.21 (e.g., 28. *catedral* [cathedral]) with a mean value of 2.52 and a median of 2.45. The majority of the pictures were rated with low visual complexity scores (125 pictures – 79.6%). Only 32 pictures (20.4%) were rated between 3.01 and 4.21 (e.g., 40. *mosca* [fly]). Ratings for visual complexity in the present work are similar to the ones obtained in previous studies (e.g., Bonin et al., 2003; Dimitropoulou et al., 2009; Snodgrass &Vanderwart, 1980). Moreover, the values for visual complexity are consistent with the relatively high ratings obtained for NA because less complex items tend to be associated with higher ratings of NA (Alario et al., 2004; Mcdougall et al., 1999).

To summarize, the dataset comprises a majority of pictures with relatively high NA and low subjective frequency, concept familiarity and visual complexity ratings. These characteristics make the stimuli particularly suitable for TOT states induction and resolution experiments, as well as to other picture naming or recognition research in EP.

In order to explore the relation between the variables collected in this study (i.e., NA (*H*-statistic and %), subjective frequency, concept familiarity, and visual complexity) we conducted a correlation analysis (Pearson product-moment correlation coefficient) (see Table 2).

Table 2

Linear correlations for Name Agreement (H-statistic and %), Subjective Frequency, Concept Familiarity, and Visual Complexity for the 157 pictures

	H	%	Subj. Freq.	Fam.	VC
H	-	-.94**	-.19*	-.25**	.33**
%		-	.16*	.22**	-.26**
Subj. Freq.			-	.97**	-.41**
Fam.				-	-.47**
VC					-

Note. *H* = *H*-statistic Name Agreement; % = percentage of Name Agreement; Subj. Freq. = Subjective Frequency; Fam. = Concept Familiarity; VC = Visual Complexity.

*. Correlation is significant at the 0.05 level (2-tailed); **. Correlation is significant at the 0.01 level (2-tailed).

According to Table 2 all correlations between the four variables were significant and globally in the same direction as correlation analyses developed by previous similar studies (e.g., Alario & Ferrand, 1999; Bonin et al., 2003; Snodgrass & Vanderwart, 1980). It is worth noting that the analysis of the respective scatterplots showed the absence of obvious outliers that could have severely biased the correlation coefficients. Both measures of NA (*H*-statistic and %) were expected to be highly and negatively correlated because increasing values of *H*-statistic indicate decreasing levels of NA (%) ($r = -.94$, $p < .01$). Moreover, the highly significant positive correlation between subjective frequency and familiarity ($r = .97$, $p < .01$) shows that these two variables are very closely related, as previously observed in other studies (e.g., Snodgrass & Vanderwart, 1980). However, it is important to note, as Balota and colleagues pointed out (2001), that both variables are frequently semantically confounded. If the researcher seeks to separate the effects of frequency or familiarity, this ambiguity should be carefully taken into consideration. Instructions considering explicitly the frequency of use (subjective frequency) or the frequency with which one comes in contact with or thinks about the concept (concept familiarity) should be extremely clear in order to minimize possible confounds and extract the independent value of each measure.

NA (%) correlated positively with subjective frequency (*r* = .16, *p* < .05), as well as with concept familiarity (*r* = .22, *p* < .01), as obtained in previous studies (e.g., Alario & Ferrand, 1999; Bonin et al., 2003). These correlations emphasize the fact that the more familiar and frequent a concept depicted by a picture is, the higher the NA ratings tend to be, since there is less dispersion of possible designations for items that are more familiar to the observer (Mcdougall et al., 1999). The participant is more prone to answer accurately to a picture that he/she is more familiar with than to pictures the participant is less familiar with.

Negative correlations were also observed concerning visual complexity ratings. This attribute correlates negatively with NA (%: *r* = -.26, *p* < .01; *H: r* = .33, *p* < .01), a result that was also found in previous studies (e.g., Bonin et al. (2003) - *r* = -.17, *p* < .05). Because more complex pictures are usually associated with lower accuracy (Alario et al., 2004; Mcdougall et al., 1999), NA ratings tend to be lower for pictures scored as visually complex. Visual complexity also correlated negatively with subjective frequency (*r* = -.41, *p* < .01), and concept familiarity (*r* = -.47, *p* < .01), which is well documented in the literature (e.g., Alario & Ferrand, 1999; Forsythe, Mulhern, & Sawey, 2008; Snodgrass & Vanderwart, 1980; Tsaparina et al., 2011). Alario and Ferrand (1999) stated that this correlation determines a trend for pictures with high visual complexity scores to be less familiar than simpler pictures. However, since it is difficult to obtain a balanced distribution of stimuli in most studies, this statistical interpretation is somewhat problematic and can be considered equivocal (Forsythe et al., 2008). For instance, in the present study, only one picture presented ratings between 4.01 and 5.00 (28. *catedral* [cathedral] – visual complexity = 4.21). According to Forsythe and colleagues (2008), it seems that as the exposure to the concept increases (i.e., as the concepts become more familiar to the observer), the complexity of the stimuli becomes more difficult to estimate and to determine. The individual elements and details of the stimulus become less novel and therefore familiarity and visual complexity are easily confounded (Forsythe et al., 2008). In fact, Hirsh and Funnell (1995) consider that this correlation occurs because concepts with higher levels of familiarity possibly have richer memory representations. Consequently, the amount of details turns out to be less relevant for the recognition of the stimulus. Nevertheless, excluding the potential limitation of the lack of a normal distribution among quartiles, the correlation obtained is consistent with previous results, where higher visual complexity ratings are correlated with lower concept familiarity and subjective frequency ratings.

In conclusion, the present work represents the first study in EP to offer norms of name agreement, subjective frequency, familiarity and visual complexity for 157 colored and tridimensional pictures that can be used in the design of research studies on cognitive psychology. As the majority of the pictures in the dataset present low frequency values, this dataset is particularly suited to studies in which TOT states induction and resolution are explored. Therefore, this database allows for a cautious and pondered selection of pictorial stimuli considering some of the most explored measures in the literature, proved to influence naming, recognition, as well as identification latencies and accuracy.

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Syllabic Pseudohomophone Priming in Tip-Of-the-Tongue States Resolution: The Role of Syllabic Position and Number of Syllables[2]

Abstract

The Tip-Of-the-Tongue (TOT) state is a common experience, usually coupled with a frustrating feeling caused by the incapability of retrieving a familiar word. It is thought that TOTs occur when the semantic and syntactic information of the word is retrieved but not its phonology (e.g., Burke, Mackay, Worthley, & Wade, 1991; Dell, Chang, & Griffin, 1999; Levelt, Roelofs, & Meyer, 1999).

This study aims to further understand the role of phonology in TOT resolution. Specifically, using a syllabic pseudohomophone priming paradigm, we aim to analyze the role of the phonological syllabic position (first *vs*. last), and the number of syllables in TOT states resolution. TOT was elicited by a picture naming task, after which a lexical decision task was presented. Here, first, last or none of the phonological syllables of the target word were embedded in pseudohomophone primes. Results showed a significant syllabic pseudohomophone priming effect facilitating TOT resolution. The effect was stronger for four-syllable long words, especially when the last syllable was used as prime. These results seem to reinforce the importance of phonology in TOT states resolution, particularly the role of the syllable as an important sublexical unit in speech processing.

The Tip-Of-the-Tongue phenomenon (TOT) is a common experience usually coupled with a strong frustrating feeling caused by the incapability of retrieving a familiar word. In spite of being a low frequency phenomenon (8-19% in lab studies), TOT is considered a universal experience (Brennen, Vikan, & Dybdahl, 2007; Schwartz, 1999), offering insight into the architecture of the human language production system.

It is commonly agreed (e.g., Burke, Mackay, Worthley, & Wade, 1991; Caramazza, 1997; Dell, 1986; Dell & O'Seaghdha, 1991; Levelt, Roelofs, & Meyer, 1999; MacKay, 1987), that the retrieval of a word requires previous activation of a concept and access to its semantic components, followed by the activation of its syntactic properties. Activation of the phonological components occurs after these two levels have been achieved (James & Burke, 2000).

Usually, semantic, syntactic and even some phonological information of the word in TOT is retrieved, though not the entire phonology (e.g., Biedermann, Ruh, Nickels, & Coltheart, 2008; Vigliocco, Antonini, & Garrett, 1997; Vigliocco, Vinson, Martin, & Garrett, 1999). TOT states have been studied as important evidence for the existence of two stages of speech production since there is

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access to the semantic and syntactic components of the word (Brown & McNeill, 1966; Vigliocco et al., 1997), but at that particular moment it is difficult to retrieve its phonological and phonetic characteristics (Damian & Martin, 1999). However, models differ in the way they conceptualize the order in lexical access and the direction of the connections between levels of processing.

On the one hand, connectionist approaches (Caramazza; 1997; Dell, 1986; Dell & O'Seaghdha, 1991; Mackay, 1987) state that there is an overlap of lexical selection and phonological encoding stages, with a permanent interaction between levels allowing any selected word to be phonologically encoded. Moreover, some activation can be spread back from the phonological word form to semantic and syntactic levels (Bock, 1996; Damian & Martin, 1999). On the other hand, according to Levelt's model (Levelt, 1989; Levelt et al., 1999), the production process is staged, from the semantic and syntactic levels (*lemma*) to phonological word form retrieval; the phonological encoding starts after the lexical selection is completed, and the information spreads only in one direction. Therefore, only the selected lemma will be phonologically encoded and the phonological word form cannot intervene in the lemma activation. Moreover, the word-form retrieval seems to occur in three main steps: first there is the morpheme encoding, followed by the phonological encoding (providing the phonological word information, including its segments, number of syllables, and stress pattern), and finally there is the phonetic encoding. It is during this final step of word-form encoding that speakers have access to the "mental syllabary" (Levelt, 1992; Levelt & Wheeldon, 1994), storage of ready-made motor programs for at least the most highly frequent syllables. Low-frequency syllables are assembled on-line, according to segmental and metrical rules of a specific language. Therefore, the syllabification is a late process in lexical access and the syllables are not represented in the mental lexicon (Levelt et al., 1999).

Meyer and Bock (1992) showed that TOT resolution was more effective when a phonological cue was presented as opposed to semantic or non-related cues. In fact, several studies have found reliable effects of phonological priming in TOT states induction (particularly syllabic), both in preventing its occurrence (e.g., James & Burke, 2000), and facilitating its resolution (e.g., Abrams, White, & Eitel, 2003; James & Burke, 2000; Meyer & Bock, 1992; White & Abrams, 2002). According to the Transmission Deficit Hypothesis (TDH - Burke et al., 1991), TOTs occur because of a problem in the inter-level connection. The activation from the semantic and syntactic to the phonological level seems to be insufficient for the word form to be retrieved. TDH is based on the Node Structure Theory (NST) (Mackay, 1987), considering that there is an extended interconnected network that contains several nodes organized in different levels of processing. In each level (semantic, syntactic, and phonological), only the node that receives and accumulates most priming will become activated, according to the “most-primed-wins principle” (Mackay, 1987). In this case, priming works as sub-threshold excitation that prepares a node for possible activation. The first node to accumulate sufficient priming to become activated is the one that gets its information retrieved. If lack of priming incites an activation deficit of the phonological nodes a TOT state might occur. According to connectionist theories, phonological priming effects prevent TOTs induction and facilitate its resolution by feedback connections from word form nodes to semantic and syntactic nodes (e.g., James & Burke, 2000; Meyer & Bock, 1992; White & Abrams, 2002). This means that lexical features can modulate phonological components and vice-versa. Therefore, if someone in a TOT state is confronted with a phonologically related word, the phonological features of this alternative word will be activated. Given the phonological overlap between both words, there will be an increase of the accumulated priming of the TOT word. This way, the TOT word reaches the activation threshold necessary to be selected, allowing its correct retrieval (Dell & O’Seaghdha, 1991; Roelofs, 2003). Moreover, according to James and Burke (2000) a major phonological overlap between the prime (related word) and the word that causes TOT (target word) is not required for this facilitation to occur. In fact, a single phonologically related syllable embedded in an alternative prime word was enough to reinforce the phonological connections and, consequently, to resolve the TOT state.

Levelt and colleagues (1999) also consider the effects of phonological priming in their theory of serial lexical access and confirm that if a subject is presented with phonological segments, these could affect the correspondent segment nodes in the production system, creating a link between the segments that are perceived and the ones that should be produced. When a TOT state occurs, there is a feedback loop through the perceptual network that sends the uncompleted form of the TOT word to the conceptual system (first level of speech production). Here, there is activation of the lemmas of the phonologically related words that will subsequently activate its compatible morpheme representations. These, in turn, activate the corresponding syllable program nodes (Roelofs, 2003). Hence, the existence of this loop allows the selection of the syllable programs correspondent to the TOT word, facilitating its production and resolution.

Even though the different theoretical perspectives (connectionist vs. serial) consider and explain the phonological priming effects in TOT induction and resolution, up till now there is scarce investigation on the variables that intervene in these processes. Therefore, the present study presents new behavioural evidence for phonological priming effects in TOT states resolution, using an experimental paradigm that tries to overcome some of the limitations of previous used paradigms. The aim of this study is to explore the role of syllabic position and number of syllables in this process in a language with well defined syllable boundaries, European Portuguese (EP).

The syllable as a relevant processing unit has been established in the literature in the last decades. In visual word recognition research, there is a considerable amount of empirical evidence showing that recognition is faster for targets primed by the first letters that corresponded to the first syllable (e.g., *ju.nas* - *JU.NIO*), comparatively to targets that shared the first letters but not the first syllable (e.g., *jun.tu - JU.NIO*) (Álvarez, Carreiras, & Perea, 2004), the so called syllable congruency effect (e.g., Álvarez, Carreiras, & de Vega, 2000; Álvarez et al., 2004; Carreiras, Álvarez, & de Vega, 1993).

In production research the results are less consistent although most influential models of speech production (Dell, 1986; Levelt et al., 1999) assume the syllable as an important sublexical unit of speech processing. In fact, Ferrand, Segui, and Grainger (1996) were the first authors to find effects of syllable congruency using a naming task in French, a language with well defined syllable boundaries (see also Ferrand, Segui, & Humphreys, 1997, for an English study). They presented evidence for the importance of syllable structure and syllable-sized units in phonological production, even though several experiments in different languages have failed to replicate this effect in word and picture naming (Dutch: Schiller, 1998; Spanish: Schiller, Costa, & Colomé, 2002; French: Brand, Rey, & Peereman, 2003; English: Schiller, 2000). The syllable priming effect was assumed to emerge only in explicit priming paradigms (where the prime is presented late enough in the process of producing the target), since syllabification is a delayed phonological process (Laganaro & Alario, 2006; Schiller et al., 2002). The syllable primes seem to facilitate the selection of segments that become part of the stored word form (Cholin, Schiller, & Levelt, 2004). In the present study, phonological priming is presented through syllabic pseudohomophones embedded in pseudowords that are syllabically overlapped with the target word. Therefore, the syllable congruency effect seems to allow for a prediction of speech production facilitation when syllabic phonological primes are presented. Additionally, low frequency words seem to be more sensitive to several syllabic effects than high-frequency words (Jared & Seidenberg, 1990), namely to the effect of syllabic congruency (Carreiras, Riba, Vergara, Heldmann, & Münte, 2009). Thus, considering that TOT states experiments usually involve low-frequency target words (e.g., Brown & McNeill, 1966; Burke et al., 1991), it should be expected to find phonological syllabic effects in TOT induction and/or TOT resolution. Effectively, as Burke and colleagues (1991) showed, participants in TOT states are often able to account for the number of syllables in the word in TOT. Furthermore, it seems that the vast majority of subjects in TOT states is able to retrieve the first syllable or at least the first phoneme more easily than the remaining segments of the word (e.g., Brown, 1991; Brown & McNeill, 1966; Burke et al., 1991).

The first syllable seems to work as a password for the activation of all possible words in order to be retrieved (Cholin, Levelt, & Schiller, 2006) or recognized (Álvarez et al., 2000; Carreiras & Grainger, 2004; Perea & Carreiras, 1998). The importance of the first syllable in lexical access, especially in languages with well defined syllable boundaries like Spanish or Portuguese (Álvarez et al., 2000; Ferrand et al., 1996; Frota, Vigário, & Martins, 2002; Rauber, 2002; Sebastián-Gallés, Dupoux, Segui, & Mehler, 1992), seems to indicate that the phonological features of the first syllable might be retrieved faster and/or more accurately than the remaining syllables of the word. Therefore, in a TOT state these features would be easier to retrieve even when the entire phonology of the word is not. Nevertheless, there is scarce empirical evidence supporting the role of a specific syllabic position on TOT states resolution (Abrams et al., 2003; White & Abrams, 2002). White and Abrams (2002) and Abrams et al. (2003) observed that TOT states could be more easily resolved with the presentation of the first syllable than with the last or the middle syllables of the TOT word. The authors explain their results based on the NST, stating that there is a "sequential nature of activation of phonology", placing "importance on the initial part of a word for achieving activation of the entire word" (Abrams et al., 2003; p. 1154). In the present study, the role of the phonological syllabic position was explored to verify if the effects found by Abrams and colleagues in English (Abrams et al., 2003; White & Abrams, 2002) are preserved in European Portuguese (EP). Compared to English, EP is a syllable-timed language with a regular syllable structure and well defined syllable boundaries (Frota et al., 2002); the preferred stress pattern in this language is the penultimate syllable, and orthography is more transparent. Several studies have claimed that Romance languages (e.g., Portuguese, Spanish, French, Italian) differ from Germanic languages (e.g., English, Dutch, German) in the way syllables are organised into words (e.g., Croot & Rastle, 2004; Schiller et al., 2002). This may suggest that the role of the syllable may differ between languages. More specifically, the fact that some syllabic effects emerge more consistently in syllable-timed languages, may predict that syllables are relevant representational units for Romance languages but not for stress-timed languages. Among the Romance languages, the transparency of the mapping between graphemes and phonemes of EP is higher when compared to French and lower when compared to Spanish. The literature on phonological priming in Romance languages is still insufficient, particularly on TOT resolution. For these reasons, we expected to observe robust syllabic priming effects for EP. The results will allow a deeper understanding of how phonology can facilitate production in a language with different characteristics and verify whether there is maintenance of found effects, extended to languages other than English.

Additionally, this study also aims to explore the role of the number of syllables of TOT words, a forgotten variable in TOT states resolution research, especially because there seems to be evidence for the importance of this variable in speech production. For instance, Klapp, Anderson, and Berrian (1973) were the first authors to present an effect of number of syllables (word length) in a picture naming task, with participants being slower in producing disyllabic than monosyllabic words. More recently, Meyer et al. (Meyer, Belke, Häcker, & Mortensen, 2007; Meyer, Roelofs, & Levelt, 2003) also obtained a word length effect although only in pure presentation blocks (in which all presented items have the same length). Previous studies (Ferrand & New, 2003; Roelofs, 2002; Santiago, MacKay, Palma, & Rho, 2000) using several production tasks have shown that shorter words are produced faster and more accurately than longer words, although very few studies used polysyllabic words. As Perry, Ziegler, and Zorzi (2010) pointed out, in contrast to monosyllabic words, syllabification strategies and stress assignment must be taken into account when considering longer words. Therefore, these mechanisms should be explicitly implemented in models of speech production and recognition, which are in general and up to now, developed taking in consideration mostly monosyllables. Interestingly, a large-scale study conducted by Bates et al. (2003) showed that the number of syllables is a good predictor for naming latencies for the Romance languages (Spanish, Italian) but not for Germanic languages (English, German). Moreover, Jared and Seidenberg (1990) considered that the effects of the number of syllables are only significant for low-frequency words, making the manipulation of this particular variable extremely relevant in TOT states resolution studies. According to NST, shorter words are retrieved faster because they require activation of less syllabic nodes (Santiago et al., 2000). The effect of number of syllables in naming seems to reflect the importance of the syllable in phonological encoding mechanisms. Damian, Bowers, Stadthagen-Gonzalez, and Spalek (2010) stated that the entire word has to be phonologically encoded in order to initiate the word production. Being TOT a state where phonological encoding does not achieve the activation threshold, the effect of number of syllables might emerge, with longer words being more likely to induce TOT states than shorter words.

On TOT literature, only one previous study explored the effect of number of syllables, although the authors did not directly manipulate or consider word length as their main variable. Harley and Bown (1998) showed that longer words produce more TOT states than shorter words. This variable was considered in an *a posteriori* analysis attempting to control the phonological neighbourhood density in a TOT state inducing experiment. Moreover, they did not evaluate its impact in TOT states resolution, as it is intended in the present work.

In this study, the fundamental goal was to explore the phonological priming effect in TOT states resolution in a different language (EP), considering how syllabic position and number of syllables can affect word retrieval. A picture naming paradigm was used to induce TOT because in studies where definitions are used to induce TOT, the obtained results can be biased by semantic clues within the definition. Therefore, the use of pictures to induce TOT seems to be a stronger methodological option, allowing for a more controlled naming procedure.

In order to explore the role of syllabic position in TOT resolution, syllabic pseudohomophones were used as primes – i.e., pseudowords that share the phonological representation of one of their syllables with the TOT word (target), although their orthographic representation may differ. The use of syllabic pseudohomophones in TOT states resolution studies that aim to explore the role of phonology may carry some methodological advantages. In fact, its use allowed for a control of the part-of-speech effect recently established by Abrams and Rodriguez (2005): if prime and target share the same grammatical class the prime word might inhibit the target production. Besides, syllabic pseudohomophones were used to strength prime-target phonological links, attenuating orthographic and semantic effects present in homophones or real words.

In sum, it is expected that participants will resolve TOT states more easily after the presentation of phonologically related primes rather than after unrelated primes, as found in aforementioned studies (James & Burke, 2000; Meyer & Bock, 1992). Moreover, and according to the previous results on syllable position presented by Abrams et al. (Abrams et al., 2003; White & Abrams, 2002), we hypothesized that primes phonologically related by the first syllable would more likely improve TOT resolution than primes related by the last syllable. Considering the effect of number of syllables, even though there is scarce evidence on this effect, a larger number of induced TOTs was expected for longer words since a larger number of syllabic nodes are necessary to be activated, making it more difficult to select when a phonological deficit of activation is present. Although there are no previous studies on the effect of number of syllables in TOT states resolution, the same argument might be advanced to the resolution of TOT states, that is, we expected a lower percentage of TOT resolution for longer words due to their higher number of nodes, making its activation easier and less time consuming.

Experiment

Method

Participants

One hundred eighty five undergraduate students from University of Minho (Portugal) participated in this study. Forty five participants were excluded from data analysis because: (i) they were not EP native speakers (12 participants); (ii) they were considered bilinguals (presented a high level of proficiency in other languages in spite of being EP native speakers) (11 participants); and (iii) there were technical problems in data collection (12 participants). Bilinguals were excluded because it has been proved that these participants can have a higher percentage of TOTs that can be affected if the target word is a cognate [i.e., equivalent translations that share form and meaning - e.g.: funnel (English)-*funil* (EP)] (Gollan & Acenas, 2004). Thus, for data analysis, we considered the answers of 150 monolingual participants, all native speakers of EP (124 female, 26 male; M = 20.65 years, SD = 2.28).

Materials

Picture stimuli were selected from a pilot study previously developed to choose the pictures that: (i) induced more TOT states; and (ii) had a higher rate of name agreement in order to minimize the occurrence of negative TOTs. A TOT is called negative when the participant TOT word is different from the target word manipulated in the experiment, which means it has to be excluded from the analyses. The average percentage of name agreement (NA) for the pictures selected for the study was 85.31% (SD = 15.68). Pictures were collected from different image databases, such as Google Images (www.images.google.com) or the Multimost Stimulus Set (Schneider, Engel, & Debener, 2008). Colour pictures on white backgrounds were used with dimensions of approximately 14 x 16 cm, with a 37.00 pixel/cm resolution.

From this preliminary study we selected 99 pictures, 33 of each word length (two, three or four-syllable long), to which nine more were added for practice trials. Considering the number of syllables, target words did not differ statistically in frequency, F (2, 78) = .97, p = .384 (disyllabic words: M = 8.01, SD = 17.53; trisyllabic words: M = 5.62, SD = 15.94; four-syllable long words: M = 2.50, SD = 2.64), familiarity, F (2, 23) = .77, p = .476 (disyllabic words: M = 2.13, SD = 0.44; trisyllabic words: M = 2.28, SD = 0.71; four-syllable long words: M = 2.52, SD = 0.77) or NA, F (2, 97) = .11, p = .899 (disyllabic words: M = 86.29, SD = 15.29; trisyllabic words: M = 85.19, SD = 15.29; four-syllable long words: M = 84.48, SD = 16.82).

A visual lexical decision task (LDT) was associated with each of the 99 pictures selected (targets). A total of fourteen stimuli (words and pseudowords) was presented in a LDT after each picture, in a between-subjects design, in order to manipulate the syllabic position. Each stimulus was presented until the participant responded or until 2500ms, if no answer was given. Thus, the LDT task took a maximum of 35 sec per picture. Of the fourteen stimuli, there were four pseudowords with syllabic pseudohomophones phonologically related with the target word; four pseudowords not related to the target word; and six words not related to the target. Words were introduced as fillers so that participants did not realize the connection between tasks. Three experimental conditions were created: the First Syllable Group saw syllabic pseudohomophones related by the first syllable; the Last Syllable Group saw syllabic pseudohomophones related by the last syllable; and finally, for the Control Group, none of the pseudowords were related to the target word.

Since one third of the targets were disyllabic words we did not manipulate the middle syllable as prime. For that reason, only first and last syllables were manipulated. Furthermore, for the syllabic pseudohomophones no other parts matched the target. The remaining pseudowords and words were not phonologically, orthographically, or semantically related to the target. For instance, for the EP word *pincel* (/pĩsɛɫ/, “paintbrush”), the first syllable could be written *pin* or *pim*, and the last syllable *cel* or *ssel,* because *in* and *im* both represent the sound [ĩ], and *ce* or *sse* both represent the sound [sɛ]. Figure 1 shows an example of words and pseudowords presented for the target word *pincel*, “paintbrush”, in each of the three groups. The syllabic pseudohomophones have been underlined and the words are written in bold.

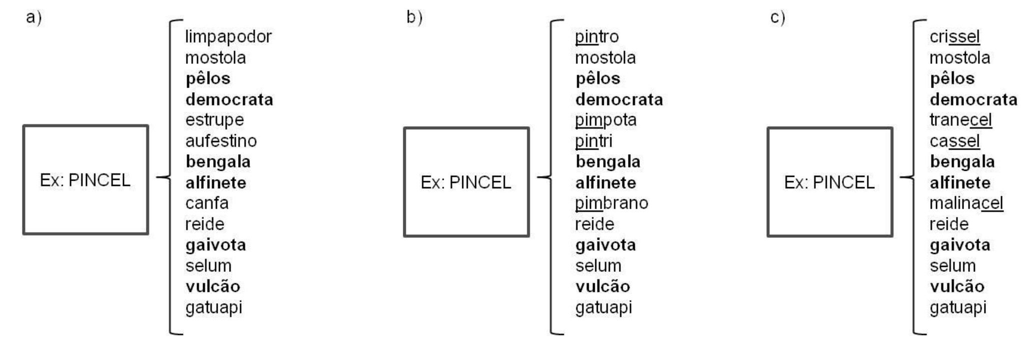

Figure 1. Example for the target word *Pincel* (paintbrush) where (a) represents the words and pseudowords presented for the Control Group, (b) represents the words, pseudowords and syllabic pseudohomophones presented for the First Syllable Group, and (c) represents the words, pseudowords and syllabic pseudohomophones presented for the Last Syllable Group.

The number of letters shared per syllable did not differ statistically by syllabic position, $t(98) = -1.74$, $p = .09$, or by number of syllables (two, three and four-syllable long words) in each position: first syllable, $F(2, 96) = 2.56$, $p = .082$; last syllable, $F(2, 96) = 1.54$, $p = .220$. The Kruskal-Wallis test used to evaluate the orthographic overlap within the syllabic pseudohomophones across conditions showed no statistical differences considering the target length (number of syllables) in the first syllabic position, $H(2) = .34$, $p = .844$, or the last one, $H(2) = 2.72$, $p = .256$.

Four different lists were created to counterbalance order effects of the primes. Participants were randomly assigned to each list.

Procedure

Three different interconnected experimental tasks were performed, as indicated in grey in Figure 2.

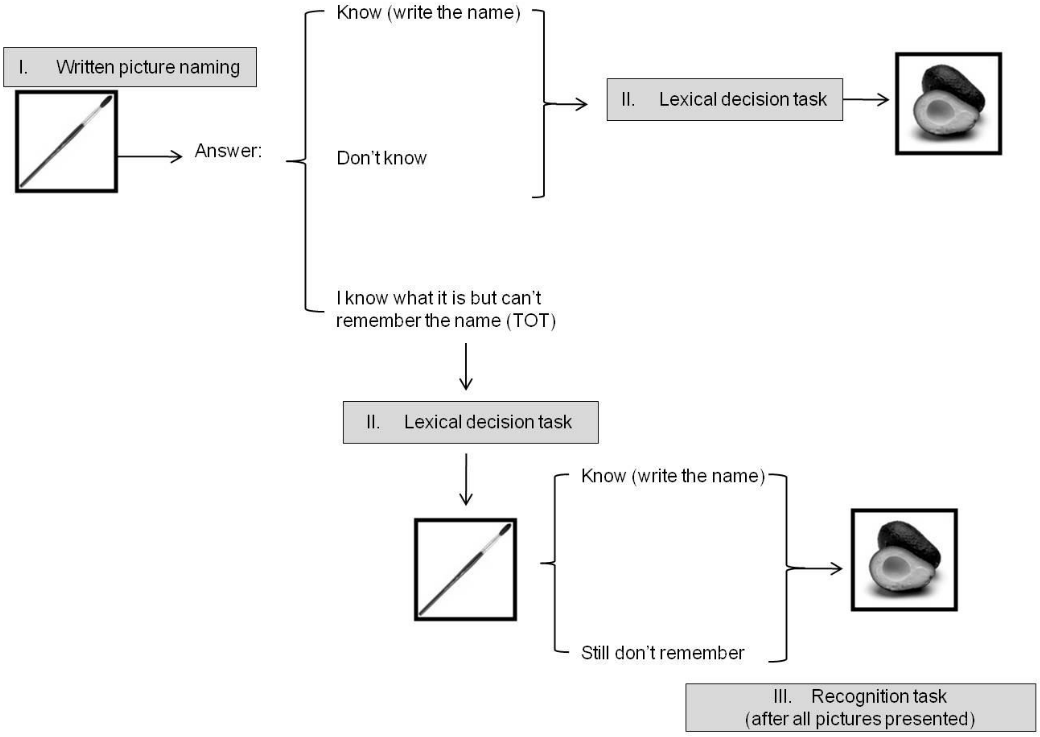

Figure 2. Experimental procedure used to induce TOT. The pictures represent sequential written picture naming tasks presented in the experiment. The recognition task was shown at the end of the experiment, after the presentation of all the pictures (99 experimental pictures + 9 for practice trials).

To induce TOT, a written picture naming task was developed. Each picture was presented for 5500ms with three possible answers: (i) *Know*, (ii) *Don't Know* or (iii) *TOT* state, all associated with three different keyboard keys. Irrespective of the participants answer, a LDT was performed. In this task, each item was presented for 2500ms and the participant had to decide if the item was a word or a non-word. Participants were encouraged to respond as quickly and accurately as possible.

After each LDT, participants who had initially answered *Know* or *Don't Know* continued to the next picture, whereas those who had answered *TOT* were presented with the previous picture once more. Participants had a second chance to write the correct word, i.e., to resolve the TOT state.

A recognition task was performed at the end of the whole procedure which allowed for the distinction between positive and negative TOTs. For the pictures that had induced TOT (independently of having been resolved or not), participants were asked to choose the name that they were considering during the experiment between three possible designations. The provided designations were chosen from the most frequent answers given in the pilot study (e.g., for the target word *pincel*, "paintbrush", the two possible alternatives apart from the correct word were: *trincha*, "brush"; and *pintura*, "painting").

The whole procedure lasted approximately 50 minutes per participant. SuperLab 4.0 (Cedrus Corporation, 2006) software was used to present stimuli and collect data.

Results

Results are presented in three major sections. First, we present the descriptive results concerning TOT induction (i.e., the first moment of written picture naming). Secondly, we present results concerning TOT resolution. Finally, *a posteriori* analysis is presented in order to discard some possible interfering variables. The statistical package IBM SPSS 19 was used to conduct these analyses.

TOT induction

Figure 3 presents the percentages of *Know*, *Know (different word)* (i.e., when the participant answered *Know* but wrote a different word from the target), *Don't Know* and *TOT* answers by number of syllables.

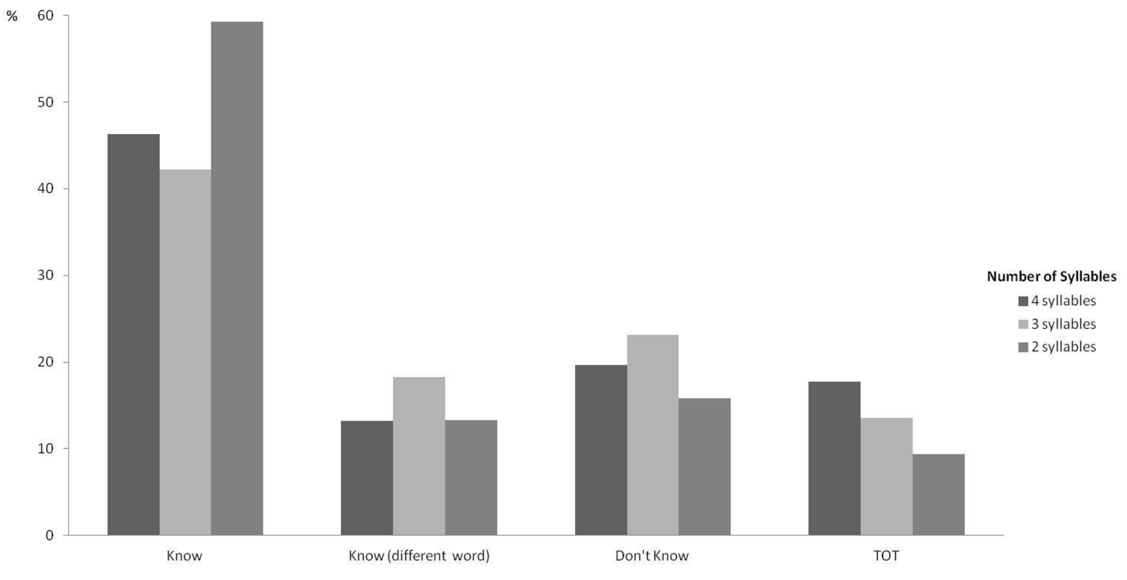

Figure 3. Know, Know (different word), Don't Know and TOT answers by number of syllables.

Results showed an average of 46.3% (*SD* = 26.8) of *Know*, 14.9% (*SD* = 13.4) of *Know (different word)*, 19.6% (*SD* = 18.6) of *Don't Know*, 13.6% (*SD* = 7.5) of *TOT* state answers, and 6.6% of missing answers. The number of TOTs in this study was comparable to the percentages found in previous studies – 7.9% to 14.6% (see Meyer & Bock, 1992; James & Burke, 2000). From the total average of 13.6% of TOT answers, 17.7% occurred in four-syllable long words, 13.6% in trisyllabic words, and 9.4% in disyllabic words. A one-way ANOVA considering the number of syllables showed that these differences were statistically significant, F (2, 96) = 10.00, p < .001. From the total percentage of TOT states, 72.1% were considered positive TOTs (i.e., the participant's TOT word was the same as the word manipulated in the experiment).

TOT resolution

Only the positive TOTs were considered for subsequent analysis. Table 3 shows the percentages of TOT resolution on the second retrieval moment (i.e., using pictures that induced TOT in the first moment) by Syllabic Group (first, last and control group) and Number of Syllables (two, three or four syllables).

Table 3

Mean % and standard deviations (SD) of TOT resolution by Syllabic Group and Number of Syllables

	Control Group % (SD)	1st Syllable Group % (SD)	Last Syllable Group % (SD)	Mean %
2 syllables	3.23 (3.28)	15.96 (12.44)	19.49 (14.51)	12.89
3 syllables	2.42 (2.92)	25.86 (13.34)	26.97 (16.46)	18.42
4 syllables	3.74 (3.97)	29.60 (16.56)	37.88 (20.51)	23.74
Mean %	3.13	23.81	28.11	55.05

An ANOVA for repeated measures was conducted by subjects (F_1) and by items (F_2) for the percentage of resolved positive TOTs based on a 3 (Syllabic Group: first, last and control group) x 3 (Number of Syllables: two, three or four syllables long words) experimental mixed design. Bonferroni correction for multiple comparisons was used. Greenhouse-Geisser correction values were considered due to sphericity assumption violation.

ANOVA results showed a main effect of Syllabic Group, F_1 (2, 147) = 20.92, p < .001, η^2 = .22; F_2 (1.73, 166.12) = 149.60, p < .001, η^2 = .61; a main effect of Number of Syllables, F_1 (1.88, 276.34) = 38.30, p < .001, η^2 = .21; F_2 (2, 96) = 9.10, p < .001, η^2 = .16; and an interaction effect of Syllabic Group x Number of Syllables, F_1 (3.76, 276.34) = 8.48, p < .001, η^2 = .10; F_2 (3.46, 166.12) = 6.63, p < .001, η^2 = .12.

The Syllabic Group effect revealed that the Control Group presented less TOT resolution when compared to both First (p < .001) and Last Syllable (p < .001) groups in the subjects as well as in the items analysis. The Last Syllable Group showed the highest percentage of TOT resolution despite the fact that these differences were only statistically significant in the items analysis (p = .002) when compared to the First Syllable Group.

Additionally, the main effect of Number of Syllables showed that four-syllable long words had more TOT resolution than trisyllabic words (the differences reached statistical significance only in subjects analysis: $p < .001$), and disyllabic words ($p < .001$, by subjects and items analysis). Besides, trisyllabic words were more retrieved than disyllabic words (differences statistically meaningful by subjects analysis: $p < .001$).

Figure 4 represents the Syllabic Group x Number of Syllables interaction effect.

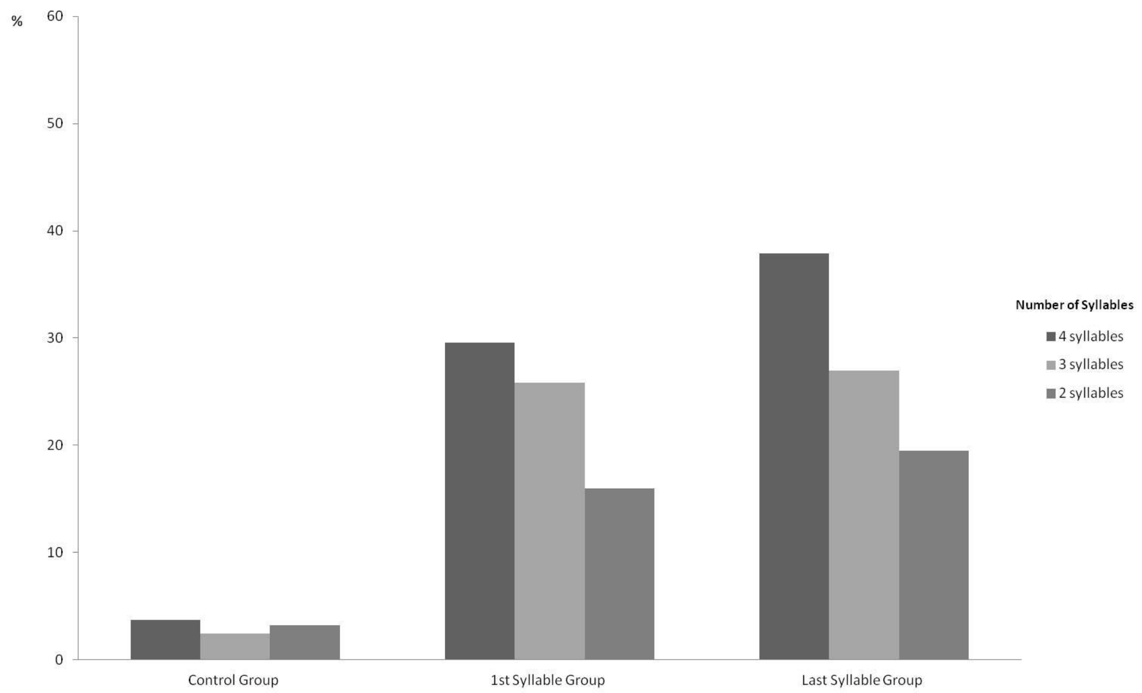

Figure 4. Percentage of TOT resolution by Syllabic Group (Control, First Syllable and Last Syllable) and Number of Syllables (two, three or four-syllables).

In order to simplify the results presentation, the differences between the Control Group and the First and the Last Syllable Group are not represented in Figure 4. However, all the differences were statiscally significant when the Control Group is compared to the First Syllable Group, $t(98) = 13.35$, $p < .001$; and to the Last Syllable Group, $t(98) = 12.05$, $p < .001$.

Within the Control Group there were no significant differences considering the target's number of syllables, $F_1(2, 146) = .43$, $p = .65$, $F_2(2, 96) = 1.24$, $p = .30$. However, in the First Syllable Group, four-syllable long words had more TOT resolution than disyllabic words ($p < .001$, $p = .002$, by subjects and items respectively). Besides, more trisyllabic words were retrieved than disyllabic words ($p < .001$, $p = .034$, by subjects and items respectively). Similarly, in the Last Syllable Group, four-syllable long words had more TOT resolution than trisyllabic words ($p < .001$, $p = .037$, by subjects and items respectively), and disyllabic words ($p < .001$, by subjects and items). Additionally, more trisyllabic words were retrieved than disyllabic words, despite these differences were only statistically meaningful in subjects analysis ($p < .001$).

Moreover, results indicated that for disyllabic words the Control Group presented less TOT resolution when compared to the First Syllable Group ($p = .012$, $p < .001$, by subjects and items respectively), and to the Last Syllable Group ($p < .001$, by subjects and items) - although the differences between the first and the last syllable groups were not statistically significant. For trisyllabic words the same pattern of results was obtained: the Control Group showed less TOT resolution than the First Syllable Group ($p < .001$, by subjects and items), and the Last Syllable Group ($p < .001$, by subjects and items), although first and last syllable groups did not differ statistically. For four-syllable long words, the Control Group showed less TOT resolution when compared to the First Syllable Group ($p < .001$, by subjects and items), and to the Last Syllable Group ($p < .001$, by subjects and items). Importantly, the Last Syllable Group showed more TOT resolution than the First Syllable Group ($p < .001$, in items analysis and $p = .083$, in the subjects analysis).

A posteriori analysis

Considering that TOT states are difficult to induce and that it is a low frequency phenomenon, researchers are frequently constrained by the characteristics of their own stimuli. Because some relevant and critical variables (syllable frequency, neighbourhood density) could not be controlled, an *a posteriori* analysis was conducted in order to discard their potential influence in the obtained results.

The syllable frequency seems to be an important variable in speech production, with most studies supporting the relevance of first syllable frequency (Carreiras & Perea, 2004; Cholin et al., 2006; Perea & Carreiras, 1998), even though Levelt and Wheeldon (1994) found a last syllable frequency effect. In both cases, it seems clear that high-frequency syllables are produced faster than low-frequency syllables. Therefore, the syllable frequency could be justifying the last syllable superiority in the obtained results. Although the syllable frequency metrics are absent in EP lexical databases, the positional frequency of the first and last phonological syllables of each experimental target – i.e., number of times the syllable appeared in that position in the P-PAL wordform database (Soares et al., 2011) – was computed afterwards in order to discard its potential influence in the obtained results.

One other variable that could be also influencing the TOT resolution results is the neighbourhood density effect (Harley & Bown, 1998). In fact, several studies have revealed that words from dense neighbourhoods are produced faster and cause fewer TOTs than words from sparse neighbourhoods (Baus, Costa, & Carreiras, 2008; Vitevitch, 2002; Vitevitch & Sommers, 2003). In this analysis we decided to include the phonological as well as the orthographic neighbourhood density, due to the transparency of EP and to the fact that the stimuli were presented visually.

An analysis of covariance (ANCOVA) was conducted for the experimental groups (First and Last Syllable groups), considering the Number of Syllables as a between-subjects factor. The syllable frequency and the neighbourhood density were added as covariates. Covariates appearing in the model are evaluated at the following values: first syllable frequency = 2083,83; last syllable frequency = 1280,09; neighbourhood density = 1,92. After controlling for syllable frequency and neighbourhood density, the analysis showed a statistically significant main effect of Syllabic Group, $F(1, 93) = 4.86$, $p = .030$, with the Last Syllable Group having a higher percentage of TOT resolution than the First Syllable Group ($p = .001$). The main effect of Number of Syllables was also statistically significant, $F(2, 93) = 11.58$, $p < .001$, with four-syllable long words presenting a higher rate of TOT resolution than disyllables ($p < .001$) and trisyllabic words (marginally significant, $p = .062$). Trisyllables had more TOT resolution than the disyllabic words ($p = .009$). The interaction effect between Number of Syllables and Syllabic Group was marginally significant, $F(2, 93) = 2.52$, $p = .086$, where, for the First Syllable Group the four-syllable words had more TOT resolution than the disyllabic words ($p < .001$), and trisyllables had more TOT resolution than disyllables ($p = .002$). For the Last Syllable Group, the four-syllable long words distinguished from trisyllables ($p = .016$) and disyllables ($p < .001$) presenting more TOT resolution.

The last syllable frequency and the neighbourhood density were not statistically significant. However, the first syllable frequency presented an significant effect, $F(1, 93) = 4.90$, $p = .029$. Planned contrasts revealed that for the First Syllable Group, longer words have marginally higher syllable frequency than shorter words, $t(93) = -2.00$, $p = .048$.

General Discussion

The main purpose of this study was to analyse the role of the phonological syllabic position and number of syllables in TOT resolution using a syllabic pseudohomophone priming paradigm. The background hypothesis was that participants in a TOT state would retrieve the target word more easily after being exposed to a phonologically related prime, especially when related by the first syllable. Moreover, although international research has not yet deeply explored the potential effect of number of syllables in TOT states resolution, it was hypothesized that shorter words would induce less TOT states and more TOT resolution than longer words.

Besides exploring a new variable in TOT resolution studies (number of syllables) in a language with well defined syllable boundaries as the EP, this study sought to overcome some of the methodological limitations of previous research. The use of a written picture naming task to induce TOT states (instead of the classic and frequently used definitions procedure), as well as the use of syllabic pseudohomophones primes allowed us not only to prevent the effect of semantic and/or syntactic information inadvertently present if real words or homophones were used as primes, but also to control the prime-target syntactic class effect established by Abrams and Rodriguez (2005).

Although the stimuli were presented visually, the use of syllabic pseudohomophones allowed us to highlight the phonological links. In fact, and attending to activation-based models, using pseudowords as primes would activate sublexical units (letters, phonemes, or even syllables) in a larger extent than other lexical units (orthographic or phonological neighbours) (Carreiras & Perea, 2002). Therefore, the methodological options taken in the present study seem to be of great advantage, allowing an induction of TOT states in a similar percentage as previous studies (Meyer & Bock, 1992; James & Burke, 2000) and a deeper understanding of the phonology's role (particularly the syllabic role) in TOT resolution, clarifying some inconsistency found in previous studies.

The obtained results on TOT resolution showed that the group that was not exposed to any kind of phonologically related primes (Control Group), presented a significant low rate of TOT resolution after LDT when compared to the other two groups exposed to a syllabic cue (First and Last Syllable Groups). These results showed that it was not the delay between first and second retrieval moments that allowed TOT resolution or even that this retrieval occurred due to some kind of *pop-up* phenomenon (see Brown, 1991; Burke et al., 1991). TOT resolution by syllabic pseudohomophone priming reached, on average, 26.0% against 3.1% of the Control Group. Hence, these results seem to support the idea that phonological syllable-sized units perform an important role in the process of lexical access and speech production. According to Burke's TDH (Burke et al., 1991), giving phonological information to the participant in a TOT state will reinforce phonological connections which enable a proper retrieval of the TOT word. This way, the activation accumulated in one particular phonological node will reach the activation threshold faster, allowing an accurate retrieval of information. The model presented by Levelt and colleagues (1999) can also account for these results. Specifically, if syllables are available in the perceptual system (even if embedded in pseudowords as homophones, as in our case) they can facilitate the production of the TOT word that has insufficient activation at the phonological level. According to this theory, phonological activation will directly affect the activation level of the phonologically related morpheme units in the word form level (Levelt et al., 1999). As syllabification is a late process, occurring at the phonetic encoding level, the syllabic units will accumulate more activation, allowing its production. Considering that syllables are fundamental units for both theories, and that it seems to be part of the phonological make-up of words (Laganaro & Alario, 2006), then it seems reasonable that it should have an important role in TOT states resolution. The phonological information provided by the syllabic pseudohomophones can be enhancing the syllable activation, facilitating its production. From our results and attending to the postulates of both approaches we could assume that the use of syllabic pseudohomophones seems to be an efficient mechanism facilitating TOT states resolution.

Nonetheless, it is worth noting that pseudohomophones are more difficult to reject than pseudowords in LDT (e.g., Ziegler, Jacobs, & Klüppel, 2001), which could be resulting in its positive effect on the obtained results. However, the analysis of variance for repeated measures conducted on the LDT's reaction times rejecting pseudowords and pseudohomophones did not show any significant differences, $F(2, 112) = 1.98$, $p = .143$ (pseudohomophones related by the first syllable: $M = 843.1$, $SD = 105.1$; pseudohomophones related by the last syllable: $M = 830.8$, $SD = 110.0$; non-related pseudowords: $M = 833.7$, $SD = 100.8$).

The observed results on TOT resolution seem to be modulated by the syllabic position of the primes with the ones related by the last phonological syllable having a stronger effect on TOT resolution. However, the *a posteriori* analysis seems to show the positional syllable frequency has an effect especially for the first position. Previous studies on syllabic position in TOT states resolution (Abrams et al., 2003; White & Abrams, 2002) present the first syllable as the most relevant unit on TOT resolution; however, the syllable frequency was not taken into account by these authors. Thus, the syllable frequency seems to be an important variable in speech production and should be controlled and explored in more detail in further investigation. Moreover, the fact that Abrams and collaborators do not control for the number of syllables of the target words, although they used four-syllable sized words, can also be interfering in their results, since our findings showed that the syllabic position effect seems to be especially relevant for longer words. Therefore, the syllabic position effects must be considered in conjunction with the number of syllables.

The *a posteriori* analysis showed a main effect of Number of Syllables, suggesting that even when the syllable frequency and the neighbourhood density are controlled the four-syllable long words persistently present more TOT resolution after phonological priming than trisyllable and disyllable words. The higher number of induced TOTs in longer words can be explained by NST in that four-syllable long words must activate a larger number of nodes and connect them in the correct order so that they can be produced. Therefore, and as hypothesized, the shorter words had a lower number of induced TOTs than longer words.

However, the fact that four-syllable long words produced more TOT resolution than dissyllable and trisyllable words was unexpected. This was an interesting result because the vast majority of production and recognition models based their considerations exclusively in monosyllabic words, without considering the processes of syllabification and stress assignment in longer words (Perry et al., 2010). Actually, the effects associated with longer words' recognition and production might differ from the factors influencing these phenomena in monosyllables and therefore, the generalization of the obtained results with this kind of stimuli must be taken carefully. Further investigation considering the number of syllables in TOT resolution is necessary in order to better understand how longer words are accessed and produced. In effect, the observed results seem to indicate that different mechanisms take action in TOT induction and resolution. Recognition and production studies have been showing that longer words are indeed more demanding concerning processes of encoding, recalling or production. However, these words seem to generate a higher level of lexical activation (Pitt & Samuel, 2006) and benefit from stronger lexical support (Jefferies, Frankish, & Noble, 2011). This being true, longer words might present a higher percentage of TOT resolution because, when in TOT, their baseline level of activation might be higher than the shorter words. Thus, when they receive phonological priming, the activation level that is by itself higher (according to Pitt and Samuel, 2006) plus the activation provided by the prime, will allow a faster lexical access and correct selection and, consequently, more TOT resolution. However, further research is needed in order to test this hypothesis as well as to deeper investigate the behavior of polysyllabic words in production studies, particularly concerning TOT resolution paradigms.

Conclusions

This study presents evidence establishing that the syllable position and number of syllables of the target word have a clear effect on the TOT states resolution. Additionally, the results showed that this effect seems to be independent of syllable frequency and targets' phonological neighbourhood density, which confirms the results obtained by Harley and Bown (1998) in TOT induction. These authors showed a significant effect of number of syllables independently of the number of phonological neighbours – TOT's number was greater for longer words when phonological neighbours were kept invariable.

It is also worth noting that we used EP language in this particular study, a language with well defined syllable boundaries as opposed to other languages (e.g., English or Dutch). This particular feature can also suggest the existence of cross-linguistic differences in the expected behaviour for number of syllables. In fact, several studies presented the idea that syllables might have a more relevant role in production in languages that are syllable-timed, influencing the make-up of word forms (Croot & Rastle, 2004; Schiller et al., 2002). The fact that syllable priming effects are usually found for syllable-sized languages predicts indeed an expected difference in EP behavior concerning syllabic effects, particularly, for the number of syllables. Further research is necessary which considers and controls the signed aspects (syllable frequency and neighbourhood density), and the way the effects of syllabic position and number of syllables can change according to each language characteristics (namely, the definition of syllable boundaries). Because most research is on mono- or disyllabic words, it would be worth exploring the effect of number of syllables in languages with syllable boundaries less defined and to verify how the current models can account for those results.

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Cognate status, syllable position and word length on bilingual Tip-Of-the-Tongue states induction and resolution[3]

Abstract

This study explores the role of cognate status, syllable position and word length in Tip-of-the-Tongue (TOT) induction and resolution in European Portuguese (EP; L1) – English (L2) bilinguals and in EP monolinguals, as a control. TOT was induced by a L1 and L2 picture naming task followed by a lexical decision task in which the first or the last syllable of the TOT word was manipulated in order to test its resolution. Results showed that bilinguals presented more TOTs than monolinguals, especially in L2 and for noncognate words. In L1, bilinguals revealed more TOTs for three- than for two-syllable words. Concerning TOT resolution, there were no differences between bilinguals and monolinguals. Interestingly, TOT resolution in bilinguals failed to show syllable position effects when the positional syllable frequency was considered. Nevertheless, three-syllable cognate words showed more TOT resolution than two-syllable cognate words.

A Tip-Of-the-Tongue state (TOT) is a common and universal experience characterized by the incapability of retrieving a familiar word. In Psycholinguistics, TOT is considered a very interesting phenomenon to study, offering insight into the architecture and functioning of the human language production system. Even though the majority of studies focusing on TOT states induction and resolution have been developed with monolinguals, the study of this phenomenon in bilinguals is also interesting for two reasons. On the one hand, it allows exploring the universality of cognitive principles that characterize speech production both in monolingual and bilingual populations. On the other hand, the study of TOT phenomenon in bilinguals contributes for the research proposals on how the two languages are organized and accessed cognitively. In particular, its study may disclose which variables may have a role in bilingual lexical access and if they have a similar outcome in the languages proficiently used by the bilingual.

The studies on bilingual TOT states are scarce when compared to the literature on monolinguals and have showed that the bilinguals present more TOT states when compared to monolinguals (Gollan & Silverberg, 2001; Gollan & Acenas, 2004). Gollan and Silverberg (2001) stated that this result was due to the fact that bilinguals have double the knowledge stored than monolinguals. For each conceptual representation they would have two lexical representations, one in each language. This higher number of stored lexical nodes would increase the competition for selection and the

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activation flow would have to spread over more nodes for bilinguals than for monolinguals. Interestingly, in a subsequent study, Gollan and Acenas (2004) found that a group of proficient bilinguals only presented more TOT states than monolinguals when noncognate words were considered, but not when considering cognate words. Cognates are translations that share not only form (phonologically and/or orthographically) but also meaning (e.g., *papel* in European Portuguese (EP) and paper in English), in contrast to noncognates that only share meaning (e.g., *pepino* [cucumber]). According to Gollan and Acenas (2004), the shared connections of cognates make their phonological elements more available (i.e., more activated) than the phonological elements of the noncognates since those elements are used more frequently and have higher levels of recency. In fact, according to the weaker links hypothesis (Gollan & Acenas, 2004), bilinguals present more TOTs than monolinguals because their semantic-to-phonological level connections are weakened. This is in line with what Burke and colleagues (Burke, Mackay, Worthley, & Wade, 1991) determined about the strength of these connections in monolingual populations. Specifically, it is considered that the strength of the connections is dependent on frequency of use, recency of use, and aging. Since bilinguals necessarily spend less time using words of each particular language, they may have weaker links between the levels of speech production system compared to monolinguals (Gollan & Acenas, 2004; Kroll, Bobb, Misra, & Guo, 2008). Therefore, words will have higher threshold levels of activation particularly in bilinguals' non-dominant language (L2) because they use the L2 less frequently than their dominant language (L1). Similarly, the probability of cognates to induce TOTs is lower than the probability of noncognates to do so (see also Costa, Santesteban, & Caño, 2005). The shared phonological elements increase the activation of cognate target words facilitating their selection and naming (Costa, Caramazza, & Sebastián-Gallés, 2000; Kroll, Dijkstra, Janssen, & Schriefers, 2000) and consequently reducing TOT induction.

Indeed, the relevance of phonology in TOT research has been explored previously in phonological priming experiments with TOT states in monolinguals. The presentation of phonological segments of the word in TOT not only prevents TOT states induction (e.g., James & Burke, 2000), but also facilitates its resolution (e.g., Abrams, White, & Eitel, 2003; James & Burke, 2000; Meyer & Bock, 1992; Pureza, Soares, & Comesaña, 2013; White & Abrams, 2002). Phonological priming seems to increase the amount of activation spread via feedback connections from the phonological to the semantic and syntactic levels, allowing the retrieval and production of the intended word (Bock, 1996; Damian & Martin, 1999). However, the studies on bilingual TOT induction and resolution that focused on phonological priming are still scarce. This study addresses this issue by assessing which segment of the word is more relevant for the target retrieval and production, a question that remains open in monolingual TOT research. For instance, Abrams and colleagues (2003) showed that when in a TOT state, English monolinguals had more TOT resolution after reading words phonologically related by the first-syllable than when reading words related by the last or middle syllable (e.g., for the target word contraband, the phonological related words could be: connotation, extradite or headband, related by the first, the middle or the last syllable, respectively). In contrast, Pureza and colleagues (2013) in a study with EP monolinguals found that, opposed to Abrams et al. (2003), TOT resolution was rather modulated by the last phonological syllable instead of the first one. The authors used a picture naming task to induce TOTs followed by a lexical decision task (LDT). The LDT allowed manipulating the syllable position in a more implicit way. Thus, the first and the last syllable of the target word (e.g., *pincel* [paintbrush]) were embedded in pseudowords (e.g., for the target word *pincel* [paintbrush], *pintro* and *pimpota* were primes related by the first syllable and *crissel* and *tranecel* related by the last syllable). The fact that Pureza et al. (2013) and Abrams et al. (2003) used two different languages, with a different syllabic structure (EP is a language that, in contrast to English, has well-defined syllable boundaries), could explain the observed differences between studies. The use of syllabic pseudohomophones in the study of Pureza et al. (2013) allowed strengthening prime-target phonological links, attenuating orthographic and semantic effects present in homophones or real words that might have biased the results of Abrams et al. (2003). Besides, their use allowed for a control of the part-of-speech effect found by Abrams and Rodriguez (2005) which states that the prime word might inhibit the target production when prime and target share the same grammatical class. Interestingly, Pureza et al. (2013), in an attempt to further explore the cause of the discrepancy in results, conducted a post-analysis in which the syllabic frequency for the first and last positions as well as the neighborhood densities of each target were included as covariates. These variables, even though they have revealed their importance in several language production studies (e.g., Baus, Costa, & Carreiras, 2008; Carreiras & Perea, 2004; Cholin, Levelt, & Schiller, 2006; Levelt & Wheeldon, 1994; Perea & Carreiras, 1998; Vitevitch, 2002; Vitevitch & Sommers, 2003) have been neglected in TOT studies. This analysis showed the maintenance of the syllable position effect when the covariates were considered, even though there was also a significant effect of the first syllable frequency. Since, to our knowledge, Abrams et al. (2003) did not control their targets for the signed variable, their results should be considered carefully. Nevertheless, the results from these studies highlight the importance of the syllable in speech production although they draw attention to different syllable positions in TOT resolution. Moreover, they support the claim that TOTs are caused by insufficient activation of the phonological representations that can be resolved through phonological priming. In order to present further evidence for the importance of phonology (particularly, syllabic) in TOT studies, the syllable position priming was explored in the present study, evaluating its role in TOT resolution in bilinguals.

Pureza et al. (2013) manipulated not only the syllable position but also the word length (in number of syllables) of the target. This has been a neglected variable in the study of TOT phenomenon even though previous studies have claimed the importance of incorporating words with more than one syllable in language production and perception research (e.g., Yap & Balota, 2009). In Pureza et al. (2013), results showed that more TOTs were induced by four-syllable long words than three- and two-syllable long words. The fact that longer words induced more TOTs was not surprising if we assume that longer words need to activate a larger number of nodes to be selected in comparison to shorter words (Mackay, 1987). However and unexpectedly, TOT resolution was also higher for four-syllable long words than for three- or two-syllable long words. This result was explained by the authors attending to the claim of Pitt and Samuel (2006) in which the level of activation of longer words is higher than shorter words due to the activation of more nodes needed to form the word. Thus, it is possible to consider that when in TOT, the phonological priming provided is added to the words with a higher baseline of activation, allowing for a faster retrieval of the phonological information and, consequently, for more TOT resolution. Therefore, the number of syllables of a word seems to be a relevant factor that should be considered in TOT induction and resolution studies. In particular, it seems interesting to explore if its effects are consistent in cross-linguistic studies considering languages with different definitions of syllable boundaries.

Thus, the main aim of the present research was to further explore the role of cognate status (cognate vs. noncognate), syllable position (first vs. last) and word length (two- vs. three-syllable long words) in TOT states induction and resolution in EP (L1)-English (L2) bilinguals. As a control, a group of EP monolinguals was also considered. Similarly to Pureza et al. (2013), in the present study bilingual speakers were presented with a L2 and L1 picture naming task in which cognate and noncognate target words with two or three syllables were to be named. It is worth noting that (in contrast to Pureza et al., 2013) in the present study no four-syllable long words were used because of their scarceness in English and due to the necessity to have words that in both languages (i.e., EP and English) presented similar lexical features (e.g., frequency, number of letters, number of syllables). After each picture presented, a LDT was shown in which syllabic pseudohomophones were embedded in pseudowords creating three different experimental conditions: one in which the syllabic pseudohomophones were related with the target word by the first syllable (i.e., First Syllable Group), other where the syllabic pseudohomophones were related by the last syllable (i.e., Last Syllable Group), and a third condition in which neither the words nor the pseudowords presented syllabic pseudohomophones related with the target (i.e., Control Group). With this manipulation, we were able to explore the effects of cognate status, syllable position and word length in TOT induction and resolution both in monolingual and bilingual populations. In contrast to what was observed in TOT induction studies with bilinguals, previous studies on TOT resolution have shown no differences between bilinguals and monolinguals. For instance, Gollan and Acenas (2004), and Gollan and Silverberg (2001), showed that bilinguals were equally likely to resolve TOT as monolinguals, regardless of the cognate status of the target word. Thus, even though bilinguals present more TOTs than monolinguals, they are comparable in its resolution. This made the authors consider that similar mechanisms may mediate TOT resolution in bilinguals and monolinguals. From the moment that a TOT occurs, bilinguals and monolinguals may be equally susceptible to priming or cues that help them retrieve the word in TOT. However, these previous studies are essentially focused on the proportion of TOTs resolved, independently of the variables that can manipulate this outcome. Thus, further research is crucial for the clarification of this issue. For instance, as stated above, Pureza et al. (2013) showed that the word length plays an important role in TOT resolution in monolinguals and this variable should be considered in bilingual TOT studies. The exploration of the cognate status, syllable position and word length will allow us to clarify not only where does the distinctiveness of monolinguals and bilinguals in TOT induction may rely but also if any of these variables may incite differences on their performance in TOT resolution.

In line with previous studies, it was expected that bilinguals would present more TOT states than monolinguals, especially for noncognate words. Because participants were EP-dominant EP-English bilinguals, more TOTs were predicted to be induced when performing the task in English than in EP. Concerning TOT resolution and even though Gollan and Acenas (2004) suggested that the same mechanisms are involved in TOT resolution in bilinguals and monolinguals, we expected to observe a different pattern of results for both populations. The reason is that in the present study the role of variables previously neglected as the syllable position and word length were now considered. As the syllabic effects seem to perform differently in languages with different syllabic structure and different definition of syllable boundaries (Bates et al., 2003; Croot & Rastle, 2004; Schiller, Costa, & Colomé, 2002) its effect on TOT resolution for bilinguals and monolinguals might be also different. In fact, the manipulation of these variables may bring a new insight to what is already known in TOT resolution in bilinguals. Nevertheless, since the group of bilinguals was EP dominant, it was hypothesized that a similar pattern of results to that showed in Pureza et al. (2013) with EP monolinguals could be obtained at least when performing the task in EP. Thus, we expected to observe more TOT resolution for words primed by the last syllable than by the first syllable or by none of the syllables (i.e., control group). Moreover, it was hypothesized that more TOT states would be induced and resolved by three-syllable long words than by two-syllable long words.

Experiment

Method

Participants

One hundred and twenty proficient EP (L1) – English (L2) bilinguals (75 women; *Mage* = 24.7; *SD* = 8.45) recruited from international or bilingual institutions in Portugal with EP-English education volunteered for participating in the present study.

All bilinguals were native speakers of EP and were matched on their L2 proficiency as evaluated by the Li, Sepanski, and Zhao (2006) language history questionnaire using a 7-point Lickert scale ranging from 1 (very poor proficiency) to 7 (native-like proficiency) (reading: *M* = 6.5, *SD* = .71; writing: *M* = 6.21, *SD* = .95; speaking: *M* = 6.18, *SD* = .91; listening: *M* = 6.53, *SD* = .71). Moreover, responses to this questionnaire revealed that all of them were first exposed to English earlier than 10 years old (*M* = 5.49; *SD* = 3.67) and that the frequency of use of L1 was, on average, 66% and 48% for the L2.

As a control group, 55 monolinguals, all native speakers of EP, were age-matched with the bilingual group (50 women; *Mage* = 21.69, *SD* = 4.69).

Materials

The 80 experimental pictures used in the picture naming task were selected from a pilot study. A total of 776 participants (640 EP native speakers and 125 English native speakers) evaluated 157 pictures taken from public picture databases such as Google Images (www.google.com/imghp) and presented the norms of name agreement, subjective frequency, concept familiarity, and visual complexity for each picture. These characteristics have been shown to be critical on naming latencies and memory processes, particularly in name retrieval and lexical access (e.g., Alario et al, 2004; Cycowicz, Friedman, Rothstein, & Snodgrass, 1997; Rossion & Pourtois, 2004; Sanfeliu & Fernandez, 1996). The pictures were colored on white backgrounds, with an approximate size of 580 pixels of length and a variable width. They had a resolution of 36.00 pixels/cm. The 80 pictures selected out of the 157 for the present study considered the ones that simultaneously in EP and English: (i) induced a high rate of TOT states; (ii) had a high rate of name agreement; and (iii) where designated by a word with the same number of syllables in both languages (e.g., *man.ga* [man.go]; *ci.lin.dro* [cy.lin.der]). Four pictures were added for practice trials.

Half of the experimental pictures were designated by two-syllable long words in EP and in English (40 experimental targets) and the other half were designated by three-syllable long words in both languages (40 experimental targets). Within each word length, 20 were cognate words (e.g., two-syllable long: *manga* [mango]; three-syllable long: *cilindro* [cylinder]) and 20 were noncognate words (e.g., two-syllable long: *colchão* [mattress]; three-syllable long: *pepino* [cucumber]).

The Name Agreement (NA) scores of the experimental pictures did not differ statistically between languages, $t\,(79) = -.30$, $p = .768$. It is worth noting that a high NA rate is crucial in order to minimize the occurrence of negative TOTs. A TOT is called negative when the participant TOT word (e.g., zucchini) is different from the target word manipulated in the experiment (e.g., cucumber), which means it has to be excluded from the analyses. Additionally, the words' log10 lexical frequency did not differ statistically across languages, $F\,(1, 72) = 1.31$, $MSE = .064$, $p = .257$, $\eta2 = .018$, by number of syllables [EP: $F\,(1, 67) = .37$, $MSE = .029$, $p = .544$, $\eta2 = .006$; English: $F\,(1, 75) = 2.32$, $MSE = .213$, $p = .132$, $\eta2 = .030$]; or by cognate status [EP: $F\,(1, 67) = 3.16$, $MSE = .244$, $p = .08$, $\eta2 = .045$; English: $F\,(1, 75) = 3.52$, $MSE = .324$, $p = .07$, $\eta2 = .045$]. The values were obtained from P-PAL database (see Soares et al., in press; available at http://p-pal.di.uminho.pt/tools) and N-Watch (Davis, 2005). As expected, cognates and noncognates differed statistically when considering the level of orthographic overlap (as assessed by Van Orden's algorithm – Van Orden, 1987), $F\,(1, 76) = 168.72$, $MSE = 5.504$, $p < .001$, $\eta2 = .689$. Cognate words presented higher orthographic overlap than noncognate words. Importantly, the level of orthographic overlap was not statistically significant between two and three-syllable long words, $F\,(1, 76) = 1.07$, $MSE = .035$, $p = .303$, $\eta2 = .014$. Also, the number of phonemes in EP and English did not differ between cognates and noncognates, [EP: $F\,(1, 71) = .38$, $MSE = .303$, $p = .54$, $\eta2 = .005$; English: $F\,(1, 70) = 2.91$, $MSE = 2.25$, $p = .092$, $\eta2 = .04$] and, as expected, this number differed when comparing three- and two-syllable long words [EP: $F\,(1, 71) = 45.93$, $MSE = 36.68$, $p < .001$, $\eta2 = .393$; English: $F\,(1, 70) = 72.15$, $MSE = 55.77$, $p < .001$, $\eta2 = .508$].

For each target picture (80), sixteen stimuli (eight words and eight pseudowords) were created in each language, i.e., in EP and in English (a total of 1280 stimuli per language - 640 words and 640 pseudowords). These stimuli were used in the LDT presented after each picture naming task. Here, half of the pseudowords and words were two-syllables long and the other half was three-syllables long. These materials were distributed in three experimental conditions: one in which four of the eight pseudowords shared with the target word the first phonological syllable (i.e., syllabic pseudohomophones were related by the first syllable; First Syllable Group); other where four of the eight pseudowords had syllabic pseudohomophones related by the last syllable (i.e., Last Syllable Group); and a control condition where none of the pseudowords (i.e., eight) were related to the target word (i.e., Control Group). Since LDT requires not only the presentation of pseudowords but also of words, the eight words presented per each experimental condition were selected guaranteeing that none of them was semantically, syntactically, orthographically or phonologically related with the target.

It is worth noting that the syllabic pseudohomophones created did not share other parts of the stimuli with the target word, except for the shared syllable. Furthermore, the syllabic pseudohomophones were created taking into consideration the phonological properties of the syllables, i.e., maintaining the phonotactic constraints of the target word as well as the syllable stress. Thus, they differed in orthography but maintained the original phonology of the syllable, assuring that the same amount of information (in number of letters) was given to the participants primed by the first or by the last syllable, $F(1, 78) = .39$, $MSE = .253$; $p = .533$, $\eta 2 = .005$. As an example, for the English word tiger (/'taI.g@r/), the four pseudowords with syllabic pseudohomophones related by the first syllable were: *<u>ti</u>bur, <u>tai</u>ble, <u>ty</u>eto, <u>tai</u>cycra*; and the four pseudowords with syllabic pseudohomophones related by the last syllable were: *strab<u>ger</u>, clo<u>gar</u>, civin<u>ger</u>, cedint<u>gar</u>.* Therefore, the first syllable could be written *ti*, *tai* or *ty* because the three represent the sound [taI], and the last syllable could be written *ger* or *gar* because both represent the sound [g@r] in English.

Participants were asked to perform the whole procedure in EP and English (first in one language and then in the other), making sure that every target word was presented in both languages and presented in the three experimental syllable groups (i.e., Control, First and Last Syllable groups). Four lists were created to counterbalance language and syllable position. For the group of monolinguals that performed the task exclusively in EP, two lists were created only to counterbalance order effects of the targets. Participants were randomly assigned to each list.

Procedure

The experiment was run individually in a quiet room and lasted approximately 50 minutes per participant. Participants were asked to respond as quickly and accurately as possible, trying not to make mistakes. The instructions were given written and orally. Bilinguals were informed that the first half of the experiment (i.e., the first 40 pictures) was going to be performed in one language and the second half performed in the other language. The group of monolinguals performed the task exclusively in EP.

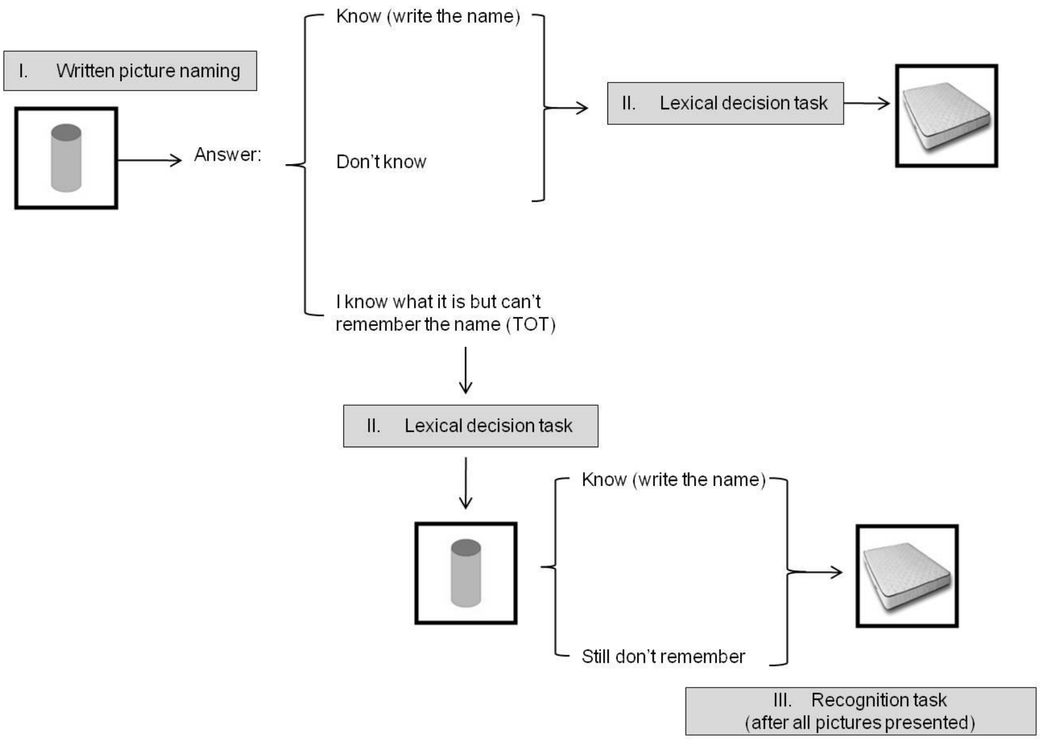

Figure 5. Experimental procedure used to induce TOT. The pictures represent sequential written picture naming tasks presented in the experiment in EP and English (separately). The recognition task was shown at the end of the experiment, after the presentation of all the pictures (80 experimental pictures + 4 for practice trials).

The three different interconnected experimental tasks used in this study are depicted in Figure 5. In order to induce a TOT state, a written picture naming task was used firstly. Each picture was showed in the centre of the computer screen for 5500 ms with three possible answers: (i) *Know*, (ii) *Don't Know* or (iii) *TOT* state, all associated with three different keyboard keys. When participants answered *Know*, they had to write the name of the object presented in the picture. It was explained to the participants that a TOT state happened when they "knew the name of the object depicted but they could not remember it in that particular moment". Secondly, irrespective of the participants answer, a LDT was performed for each target picture. In this task participants were asked to decide whether the sequence of letters string presented in the centre of the computer screen was a word or a non-word in the language in use (EP or English). The rational for the use of LDT was inducing phonological priming by presenting the syllabic pseudohomophones embedded in pseudowords. Each item was presented until a response was given or 2500 ms had elapsed. After each LDT, participants who had initially answered *Know* or *Don't Know* continued to the next picture, whereas those who had answered *TOT* were presented with the previous picture once again. This way, participants had a second chance to write the name of the picture, i.e., to resolve the TOT state. Before the presentation of the experimental stimuli, four practice trails were performed in order to assure that the instructions had been understood and any doubts could be clarified.

Finally, a recognition task was performed at the end of the whole procedure. For each picture three possible designations were presented. Participants were asked to decide which of them they had considered during the experiment. The provided designations were chosen from the most frequent answers given in the pilot study (e.g., for the target word propeller, the two possible alternatives apart from the correct word were: blade and fan). The recognition task allowed for the distinction between positive and negative TOTs, excluding the negative TOTs of the final analyses.

SuperLab 4.5 (Cedrus Corporation, 2006) software was used to present stimuli and to data collection.

Results

Results are presented in two different sections. First, we present the results concerning TOT induction on the first moment of picture naming. Secondly, we present results concerning TOT resolution, i.e., in the second moment of picture naming after the presentation of the syllabic pseudohomophones on the LDT. In each section we present the results obtained for bilinguals as well as the results of the comparison between bilinguals and monolinguals.

TOT induction

Bilinguals presented a total of 69.8% of Know answers, 13.8% of Know (different answer), 6.9% of Don't Know answers, and a total of 9.5% of TOT answers. Considering the language in which the answers were produced, in EP 75.7% were Know answers, 12.6% were Know (different answer), 3.8% were Don't Know answers, and 7.9% were TOT answers. In English, 64.1% were Know answers, 15.1% were Know (different answer), 9.9% were Don't Know answers, and 10.9% corresponded to TOT answers.

An ANOVA for repeated measures was conducted for the TOT induction answers considering the language (EP vs. English), the word length (two- vs. three-syllable long words), and the cognate status (cognate vs. noncognate word) as within subjects factors in the analysis by subjects ($F1$), and as between subjects factors in the analysis by items ($F2$). The results showed a significant main effect of language, $F1$ (1, 120) = 8.66, MSE = 2093.74, p = .004, $\eta2$ = .067; $F2$ (1, 152) = 8.23, MSE = 353.64, p = .005, $\eta2$ = .051; with more TOT states induced for English (M = 10.93; SD = .81) than for EP (M = 7.96; SD = .88). In addition, a main effect of cognate status was also observed, $F1$ (1, 120) = 11.01, MSE = 964.53, p = .001, $\eta2$ = .084; $F2$ (1, 152) = 4.38, MSE = 188.13, p = .038, $\eta2$ = .028, in which noncognates (*M* = 10.50; *SD* = .76) induced more TOT states than cognate words (*M* = 8.51; *SD* = .74).

Moreover, the interaction effect of language x word length was marginally significant in the subjects analysis, *F1* (1, 120) = 3.40, *MSE* = 254.52, *p* = .068, $\eta 2$ = .028. This interaction revealed a higher number of TOTs for three-syllable long words (*M* = 8.92, *SD* = 1.00) than for two-syllable long words (*M* = 7.15, *SD* = .95) in EP (*p* = .038). No significant difference was observed in English (two-syllable long words: *M* = 11.12, *SD* = .88; three-syllable long words: *M* = 10.83, *SD* = .97). Moreover, the number of TOTs produced by two-syllable long words differed significantly between languages (*p* < .001), with more TOTs induced in English (*M* = 11.12; *SD* = .88) than in EP (*M* = 7.15; *SD* = .95).

In order to compare bilinguals and monolinguals in TOT induction results, the group of monolinguals who performed the task exclusively in EP was compared with the group of bilinguals that named the first 40 pictures in EP. The group of monolinguals presented an average rate of 70.5% of Know answers, 13.3% of Know (different answer), 8.5% of Don't Know answers, and 7.7% of induced TOTs.

The ANOVA for repeated measures in a mixed-design considered the speaker group (bilinguals vs. monolinguals) as between subjects factor and the word length (two- vs. three-syllable long words), and cognate status (cognate vs. noncognate word) as within subjects factors in the analysis by subjects (*F1*). In the analysis by items (*F2*) the speaker group was the within subjects factor and the word length and cognate status were between subjects factors.

The ANOVA showed a main effect of speaker group in the analysis by items, *F2* (1, 36) = 6.53, *MSE* = 151.11, *p* = .015, $\eta 2$ = .154. Bilinguals (*M* = 8.54, *SD* = .99) produced more TOT states than monolinguals (*M* = 5.79, *SD* = .85). The main effect of word length was also statistically significant in both analysis, *F1* (1, 113) = 18.91, *MSE* = 1104.38, *p* < .001, $\eta 2$ = .143; *F2* (1, 36) = 9.29, *MSE* = 407.24, *p* = .004, $\eta 2$ = .205, with three-syllable long words (*M* = 9.43, *SD* = 1.05) inducing more TOTs than two-syllable long words (*M* = 4.90, *SD* = 1.05). Neither the main effect of cognate status (cognate vs. noncognate words) nor the interaction between the two factors approached significance.

TOT resolution

An ANOVA for repeated measures was conducted considering the percentage of TOTs positively resolved in the second moment of picture naming (i.e., when after the LDT, participants who had previously answered TOT had a second opportunity to retrieve the name of the picture). It is worth noting that in bilinguals, from the total of TOT states induced, 70.3% were positive TOTs (i.e., the word in TOT was the same word manipulated as target) and 71.1% of these were resolved in the second moment of picture naming.

The ANOVA for repeated measures for TOT resolution data was based on mixed design considering language (EP vs. English), word length (two- vs. three-syllable long words), and cognate status (cognate vs. noncognate word) as within-subjects factors and syllable group (first, last, or control) as a between subjects factor in the analyses by subjects (*F1*). In the analyses by items (*F2*) the syllable group was considered as a within-subjects factor and language, word length, and cognate status as between-subjects factors.

The ANOVA results showed a main effect of syllable group in the analysis by items, $F2$ (2, 304) = 7.64, MSE = 157.24, p = .001, $\eta 2$ = .048. The First Syllable Group showed significantly more TOT resolution (M = 5.78, SD = .42) than the Control Group (M = 3.81, SD = .34) ($p < .001$) and marginally significant differences in comparison with the participants of the Last Syllable Group (M = 4.59, SD = .40) (p = .074). The Control and the Last Syllable Groups did not differ significantly.

The interaction cognate status x word length was significant by subjects and marginally significant by items, $F1$ (1, 117) = 4.04, MSE = 238.39, p = .047, $\eta 2$ = .033; $F2$ (1, 152) = 3.39, MSE = 104.36, p = .068, $\eta 2$ = .022. This interaction revealed that in cognate words, the number of TOTs resolved was higher for three-syllable long words (M = 5.38, SD = .61) than for two-syllable long words (M = 4.08, SD = .57) (p = .036; p = .096, for subjects and items analyses, respectively). No differences were observed for noncognate words as a function of word length (two syllable long words: M = 5.08, SD = .56; three-syllable long words: M = 4.38, SD = .66). Additionally, the interaction language x cognate status was marginally significant in the subjects analysis, $F1$ (1, 117) = 3.63, MSE = 139.58, p = .059, $\eta 2$ = .030. This result showed that more TOT resolution tended to be found for cognate words in English (M = 5.46, SD = .58) than in EP (M = 4.00, SD = .72) (p = .084).

Similarly to what was done in TOT induction, the group of monolinguals was compared with the group of bilinguals who performed the first part of the task in EP concerning the percentage of TOTs positively resolved. For the group of monolinguals, 64.8% of the TOTs were positive, and 66.1% of these were resolved in the second moment of picture naming. It is important to note that Pureza et al. (2013) showed the relevant role of positional syllable frequency in TOT resolution in EP monolinguals in their a posteriori analysis previously mentioned. Therefore, we decided to run an ANCOVA for repeated measures based on a mixed design considering the speaker group (bilinguals vs. monolinguals) and the syllable group (first, last, control) as between subjects factors and the word length (two vs. three-syllable long words) and cognate status (cognate vs. noncognate words) as within subjects factors in the analysis by subjects (*F1*). In the analysis by items (*F2*) the speaker group and syllable group were assumed as within subjects factors and the word length and cognate status were between subjects factors. The syllable frequency of the first and the last position were included as covariates. Even though it would be advisable to control for this variable when selecting the target words for the present study, these metrics are absent in EP and English lexical databases. Moreover, due to the difficulty to find target words that induce TOT states effectively and are controlled for the variables of interest in each research setting, adding this variable as a criterion for the selected target words would reduce even more the number of available stimuli for this study. Therefore, as in Pureza et al. (2013), we computed the positional frequency of the first and last syllables of each experimental target for EP (i.e., number of times the syllable appeared in that position) from the values available at the P-PAL database for EP (Soares et al., in press). The same computation was not possible to carry out for the English targets since none of the available lexical databases, to our knowledge, provide the list of stimuli that begin or end with a given syllable. Results showed the absence of any significant differences between bilinguals and monolinguals in TOT resolution. Moreover, there were no statistically significant results for the covariates included.

General Discussion

The present study aimed to explore the role of cognate status (cognate vs. noncognate), syllable position (first vs. last) and word length (two- vs. three-syllable long words) in TOT states induction and resolution in bilinguals. TOT was induced by a picture naming task in L1 and L2, after which a lexical decision task was presented for each target picture. In this task, the syllable position was manipulated by considering syllabic pseudohomophones that shared the first, the last, or none of the syllables with the target name. Results showed that bilinguals presented more TOTs than monolinguals. Moreover, bilinguals presented more TOTs in their L2 than in their L1 especially for two-syllable long words, and more TOTs for noncognate words than for cognate words. Interestingly, when performing the task in EP, bilinguals and monolinguals showed more TOTs for three- than for two-syllable long words. Concerning TOT resolution, results showed that even though there were no differences between bilinguals and monolingual, bilinguals that were primed by the first syllable showed more TOT resolution than bilinguals that did not receive any phonological priming and tended to show more TOT resolution in comparison with bilinguals who were primed by the last syllable. Furthermore, three-syllable long cognate words showed more TOT resolution than two-syllable long cognate words. Additionally, more TOT resolution tends to be found for cognate words in English than in EP.

Consistent with previous studies on TOT states, the number of induced TOTs was higher for bilinguals (8.5%) than for monolinguals (5.8%) and similar to the percentage obtained by Gollan and Acenas (2004) (i.e., 9%). Moreover, the number of induced TOTs was higher for L2 than for L1, and higher for noncognates than for cognate words. These results confirmed our hypotheses and support the weaker links theory developed by Gollan and Acenas (2004). According to this proposal, bilinguals produce more TOTs than monolinguals because their inter-level connections are weaker than the monolinguals connections. That is due to the fact that bilinguals spend less time using words of each particular language, and since the strength of the connections depends essentially on the frequency and recency of use (Burke et al., 1991), bilinguals present more TOT states than monolinguals. The connections are especially weak in the less dominant (and consequently, less frequently used) language. Therefore, as predicted, bilinguals in the present study not only presented more TOT states than monolinguals but also more TOT states in English than in EP. The difference between languages is probably due to the difference in the frequency of use revealed by the participants (i.e., 48% for English vs. 66% for EP) that makes the connections in English weaker than in EP. Additionally, the shared features of cognate words (not only phonological but also semantic) make their connections more activated because they are used more frequently. Consequently and as expected, cognate words were less prone to induce TOT states than noncognate words.

Other interesting result observed on TOT induction is that when bilinguals had to name the pictures in EP, they revealed more TOTs for three- than for two-syllable long words, as in Pureza et al.'s study (2013) with EP monolinguals. However, in English this difference was not statistically significant. Several studies have claimed that Romance languages (e.g., Portuguese, Spanish, French, Italian) differ from Germanic languages (e.g., English, Dutch, German) in the way syllables are organised into words (e.g., Bates et al., 2003; Croot & Rastle, 2004; Schiller et al., 2002). English is a stress-timed language, in which the syllable boundaries are not well defined, while EP is a syllable-timed language with a regular syllable structure and well defined syllable boundaries (see Frota, Vigário, & Martins, 2002, for details). Thus, the present results seem to suggest that the difference obtained between languages may bring about differences in the mechanisms of lexical access and word retrieval due to different role of words' syllabic structure. Syllables may have a more relevant role in production in a language like EP, influencing the make-up of word forms (Croot & Rastle, 2004; Schiller et al., 2002). Therefore, the role of the word length seems to be highlighted in EP and not in English. The syllabic features of the languages have an effect on bilinguals' performance making them respond differently depending on the language that they are using in a given moment.

Concerning TOT resolution, the results on syllable position showed that bilinguals presented more TOT resolution when primed by the first syllable than by none of the syllables of the target word and marginally more than when primed by the last syllable. Opposed to the claimed hypothesis and to what was obtained by Pureza et al. (2013) with EP monolinguals, the present result is consistent with the one obtained by Abrams and colleagues (Abrams et al., 2003; White & Abrams, 2002) with English monolinguals. However, when comparing bilinguals and monolinguals and controlling for the effects of positional syllable frequency, the syllable position effect is no longer significant. Thus, it seems that the positional syllable frequency has a relevant role in the effect of syllable position, eliminating its effect. Since, to our knowledge, Abrams et al. (2003) did not control for the syllable frequency, their results should be taken carefully considering that they might have been biased by this variable. Therefore, further research that controls for syllable frequency is demanded in order to clarify the influence of syllable position in TOT resolution.

Furthermore and in line with previous studies (Gollan & Acenas, 2004; Gollan & Silverberg, 2001), no differences were found when comparing bilinguals and monolinguals in TOT resolution. Since new variables were included in order to determine the rates of TOT induction and resolution in bilinguals, specifically, the cognate status, the syllable position and the word length, a different outcome was expected. However, even though bilinguals had a higher rate of induced TOTs than monolinguals, the percentage of TOT resolution across bilinguals and monolinguals was similar. Therefore, when in a TOT state, both bilinguals and monolinguals are equally able to retrieve the target word, being equally susceptible to the manipulated variables explored in the present study.

Interestingly, results on TOT resolution with bilinguals showed that the effect of cognate status is modulated by the word length. Independently of the language in use, cognate words with three-syllables had more TOT resolution than cognate words with two-syllables. As mentioned, cognate words are considered to share phonological representations that increase the activation of the target, allowing a faster selection and naming (Costa et al., 2000; Kroll et al., 2000). Thus, it is possible to consider that cognate words might allow a higher contact between languages integrating information from both languages to facilitate lexical access and speech production. In fact, cognate longer words have more shared connections than shorter words, due to the higher amount of phonemes that are shared across translations. Adding the higher activation of longer words due to the selection of a higher number of nodes (Pitt & Samuel, 2006; Pureza et al. 2013) to the higher activation of cognate words facilitated the retrieval of the word in TOT. Moreover, the obtained results also showed a marginal effect in which cognate words presented more TOT resolution for English than for EP. This result is consistent with what was previously obtained on cognate recognition, showing that there is a clear advantage of cognates in comparison with noncognates when performing in L2 but not in L1, in which the data is more controversial (see Brenders, van Hell, & Dijkstra, 2011). As mentioned, cognate words may rely on the shared features across languages particularly on syllabic information from EP to help them in lexical access and selection. Being English the less frequently used language of this group of bilinguals, it seems that the phonological features shared with L1 allowed them to facilitate TOT resolution in their less used language. Therefore, they may rely on the structural characteristics of the languages especially when one of the languages has more defined syllable boundaries than the other. This way, the role of the syllable is highlighted, facilitating TOT resolution.

To conclude, the present study pretends to give a new insight on the mechanisms concerning TOT induction and resolution particularly when considering bilingual speakers. It seems of particular relevance the syllabic structure of the languages proficiently spoken by the bilingual, which seems to interact not only with the cognate status of the word in TOT but also with the word length and syllable position. Overall, the study of TOT phenomenon particularly in a bilingual population presents an important tool for investigating the variables that facilitate lexical access and word retrieval in a cross-linguistic setting.

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Bilingual performance in restricted and non-restricted verbal fluency tasks[4]

Abstract

The verbal fluency task has showed in previous studies to differentiate bilingual and monolingual speakers' performance. Compared to monolinguals, bilinguals usually produce a smaller number of exemplars when asked to name a maximal number of exemplars that belong to a given semantic or letter category. This disadvantage in bilingual performance has been previously observed to be attenuated when bilinguals are able to produce a larger amount of cognate words. The present study tried to better control for the chances of producing cognates. For that matter, an estimation of the maximum number of cognates that could be generated in the used semantic categories was calculated previously to control for a priori unequal proportions of cognates per category. Additionally, the time period for the participants to respond was increased which allowed testing the retrieval of more difficult words, providing a better description of cognate retrieval over time. Moreover, two verbal fluency tasks were presented, one in which participants could produce exemplars in an unrestricted way and other where they could only produce one single exemplar belonging simultaneously to a semantic and letter category. Results on the two different (typing) fluency tasks showed in more detail that bilinguals retrieve more cognates than noncognates, emphasizing the role of cognate words in bilingual word production.

The verbal fluency task is a speech production task in which participants are asked to produce a maximal number of words of a certain category (i.e., semantic - e.g., animals - or letter - e.g., words starting with the letter F) during a determined amount of time (usually one minute; Roberts & Le Dorze, 1997). During word retrieval in a verbal fluency task, the category name will activate multiple concepts, and the participant must select one name at a time, selecting among several alternatives (Sandoval, Gollan, Ferreira, & Salmon, 2010). Therefore, it is a very interesting task that can help to reveal the processes involved in lexical access and word retrieval. In fact, this task has been commonly used in clinical contexts (e.g., Benton, 1968; Benton & Hamsher, 1976; Lezak, 1995), to evaluate participants' ability of word retrieval. Interestingly, when applied to healthy participants, previous studies on this task reported differences in the naming performance between monolingual and bilingual speakers (e.g., Gollan, Montoya, & Werner, 2002; Michael & Gollan, 2005; Rosselli et al., 2000; Sandoval et al.,

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2010). Bilinguals seem to produce a lower number of exemplars than monolinguals especially for semantic categories. It is thought that this difference between semantic and letter categories may be related with the amount of cognate words that bilinguals are able to produce in each type of category. Cognates are translations that in addition to sharing the meaning with the target word are also similar in form (phonologically and/or orthographically) (e.g., *girafa* [giraffe], in European Portuguese (EP) and English), in contrast to noncognates that only share meaning (e.g., *macaco* [monkey]). The advantageous production of cognates when compared to noncognates has been reported by previous bilingualism studies (e.g., Costa, Santesteban, & Caño, 2005; Ivanova & Costa, 2008; Gollan & Acenas, 2004; Gollan, Montoya, Fennema-Notestine, & Morris, 2005). Thus, it is worth exploring how the production of cognate words facilitates bilingual performance in a production task as the verbal fluency task. With that proposal, the present study was developed with the aim to further explore the performance of bilinguals in a verbal fluency task trying to better control for the chances of producing cognates.

Rosselli et al. (2000) found that bilingual speakers did not differ from monolinguals on the number of words produced in letter categories, but that there were significant differences between speaker groups in semantic categories. Regarding semantic categories, bilinguals produced fewer correct exemplars than monolinguals, although some categories allowed a better performance in one language than in the other, depending on the frequency of the exemplars in the given language. For instance, if bilingual participants were more used to name animals in language A than B, performance regarding animal retrieval in language A was better than in language B. It seems reasonable to assume that bilinguals retrieve and name words that they usually produce in L1 faster than words from a specific semantic category that they are not used to produce in that language (Gollan, Montoya, Cera, & Sandoval, 2008). Although the letter fluency task is assumed to be more demanding in terms of executive control and attention, because phonemic generation is not a common strategy in word retrieval (Luo, Luk, & Bialystok, 2010), semantic fluency places a bigger load on the semantic system (Capitani, Laiacona, & Barbarotto, 1999). Gollan and colleagues (Gollan et al., 2002, 2008; Sandoval et al., 2010) replicated Rosselli et al. (2000) results, with bilinguals producing fewer correct exemplars in semantic categories. However, in letter categories there was no difference between bilinguals and monolinguals. This pattern of results in letter and semantic categories was also found in elderly populations when compared to younger adults (Bolla, Gray, Resnick, Galante, & Kawas, 1998; Crossley, D'Arcy, & Rawson, 1997; Kozora & Cullum, 1995; Tombaugh, Kozak, & Rees, 1999; Tomer & Levin, 1993) as well as in patients of Alzheimer's disease (Monsch et al., 1992). In bilinguals, one possible explanation for this result could be that they produced more cognate words in letter than in semantic categories (see also Michael & Gollan, 2005). In verbal fluency task studies (Gollan et al., 2002, 2008; Sandoval et al., 2010), monolinguals always produced more words in both types of categories (i.e., semantic and letter categories), and importantly overall more noncognate words than bilinguals. However, the higher amount of cognates produced by bilinguals in letter categories was sufficient to even out the number of exemplars produced by either group of speakers. That is, bilinguals and monolinguals may not differ in the overall number of exemplars produced in letter categories because bilinguals are able to choose from a higher proportion of cognates. In semantic categories, the number of cognates can be more limited than in letter categories, and therefore, bilinguals may be forced to produce less cognate exemplars simply because these words are not present. Therefore, the range of cognates that can be produced in each category as well as the restriction (in terms of time or type of category) that the fluency task can possibly demand may influence the number of exemplars produced by a bilingual.

Previous studies showed that cognate words are not only produced faster but are also more "resistant" to language attrition, while noncognates tend to be lost both in language attrition and in language death (see Schmid & de Bot, 2004). In the present study, the group of bilingual speakers that participated in the task were switched-dominance bilinguals, descendents of Portuguese emigrants, that were born in France and are now living in an almost exclusive L2 (EP) environment. Nevertheless it was hypothesized that, being cognate words more resistant to lack of language use, bilinguals would still present a higher percentage of cognates in a verbal fluency task when compared to a group of monolinguals. In fact, Linck and collaborators (Linck, Kroll, & Sunderman, 2009) reported evidence supporting the idea that the language context of the speaker is one key element for the activation of the representations of that language. The authors found that direct language immersion in a country in which the language-to-be-learned is the native language facilitated L2 learning by attenuating activity of the L1. In their study, immersed learners were compared to classroom learners in a verbal fluency task. Results showed that the immersed learners produced significantly more L2 exemplars than the classroom learners but significantly fewer L1 exemplars. Therefore, during immersion, participants might have shifted into a L2 mental set by reinforcing L2 representations due to continued exposure and use, and increasingly inhibited L1. This L1 use reduction or decline might happen through lack of everyday use, brain injury or caused by the effects of normal aging (Cook, 2007) and tends to increase with the length of time elapsed since the onset of attrition (Schmid & de Bot, 2004). This is a common experience for returnees' or emigrants' children that return to their home country and that may rapidly inverse their dominant language (Cook, 2007; Kanno, 2000). When L2 gradually becomes the stronger language, L1 processing will eventually reach a point where it will not only be slower but also more influenced by L2 (Köpke, 2004). The lower frequency and recency of L1 use will raise the activation thresholds of words in L1, raising the activation of the lexical representations (Paradis, 1993, 2001). The EP-French bilinguals participating in the present study moved to Portugal during youth. Their L2 (EP) has become their dominant language and L1 (French) use declined. However, cognate words seem to have lower threshold levels of activation (e.g., Costa et al., 2005; Ivanova & Costa, 2008; Gollan & Acenas, 2004) and to be more resistant to language use decline (Schmid & de Bot, 2004). Thus, in the present study it was hypothesized that this group of bilinguals would still present a higher rate of cognate production than monolinguals. If this turns out to be true, bilinguals' performance cannot exclusively be dependent on the frequency and recency of use of the non-dominant language or the language context but one has to consider the cognate status of the word retrieved.

Thus, the aim of the present study was to further explore the performance of bilinguals in a verbal fluency task trying to better control for the chances of producing cognates. For that matter, an estimation of the maximum number of cognates that could be generated in the used semantic categories was calculated previously to control for a priori unequal proportions of cognates per category. Two typing tasks were performed to better characterize the bilingual (written) word production. First, a standard verbal fluency task was used, containing semantic and letter categories (Experiment 1) with an extended deadline of five minutes. The methodological option to increase the time period for the participants to respond allowed testing the retrieval of more difficult words, providing a better description of cognate retrieval over time. Second, we used a constrained verbal fluency task (mixed task) in which participants were asked to give a single response that belonged to a particular semantic category and started with a specific first letter (Experiment 2 - e.g., ANIMALS: B). These category pairs were selected considering combinations that could equally produce both cognate and noncognate exemplars. Previous studies showed that bilinguals usually produce more cognates in letter categories than in semantic categories (Gollan et al., 2002, 2008; Sandoval et al., 2010). In a mixed task like Experiment 2 that is more demanding in terms of executive control than the less restricted verbal fluency task, we can predict that when the probability to produce a cognate and a noncognate is similar, bilinguals will be more likely to select a cognate word from among all possible candidates.

Experiment 1: Verbal fluency task

Method

Participants

The bilingual group was constituted by 24 EP-French bilinguals, born in France and descendents of emigrant Portuguese parents (17 women, 7 men; *M* = 34.75 years, *SD* = 5.73). They all filled out the Language History Questionnaire (Li, Sepanski, & Zhao, 2006) to provide ratings of proficiency in EP and French. All bilinguals stated that French was their native language (as well as EP in some cases), and that this was their dominant language while living in France (L1), although nowadays EP (L2) has become their more dominant language. Nevertheless, bilinguals participating in this study confirmed that French is spoken only in particular situations (talking on the phone with family and friends; watching French movies). These participants were balanced bilinguals in their early childhood (years spent in France: *M* = 12.88; *SD* = 3.08) who went back to Portugal during their youth, and presently live in an almost exclusive monolingual environment (years spent in Portugal: *M* = 21.67; *SD* = 4.70; see Table 4). Participants consistently testified that while living in France, they spent most of their time in French monolingual contexts except at home. When they moved back to Portugal, there was a complete language switch to EP.

For the control group, 24 EP native monolingual speakers were tested (17 women, 7 men; *M* = 23.58 years old, *SD* = 4.36). All monolinguals had a medium level of English, but no knowledge of French.

Table 4

Descriptive data on the demographics of the bilingual group

Age		Years in France		Years in Portugal		French use (%)		EP use (%)	
M	SD	M	SD	M	SD	M	SD	M	SD
34.8	5.7	12.9	3.1	21.7	4.7	26.7	26.0	94.8	10.4

Note: M = mean; SD = standard deviation; EP = European Portuguese

Materials

The verbal fluency task in Experiment 1 consisted of three semantic categories and three letter categories. In order to estimate the number of EP-French cognate words that could probably be produced in each semantic category nine of the Basety's 21 categories were translated to EP (Léger, Boumlak, & Tijus, 2008), excluding compound words. For each exemplar in Basety, the appropriate translation in EP was taken from "The Free Dictionary" (http://www.thefreedictionary.com/) and "Infopedia" (http://www.infopedia.pt/). Phonetic transcription was transferred from Lexique 3.71 (New, Pallier, Ferrand, & Matos, 2001) and revised by a phonetic expert. A word was considered to be a cognate if it needed less than three substitutions to edit one string into its equivalent translation (considering insertions and deletions), i.e., when they presented more than 0.25 Levenshtein's distance values (1.00 is obtained when two identical strings are compared; e.g., Dijkstra, Miwa, Brummelhuis, Sappelli, & Baayen, 2010).

The number of cognate words obtained for each semantic category were: animals – 32%; fruits – 35%; musical instruments – 55%; vegetables – 26%; furniture – 37%; tools – 19%; professions – 15%; vehicles – 38%; and clothing – 41%. The chosen semantic categories were "fruits", "furniture" and "clothing", because they had a good mix of cognates and noncognates as well as a good pool of exemplars possible to name in the time range available in the task. Given that there is not much (if any) literature for the letter fluency task in EP, the same estimation of number of cognates for each letter category was not possible to be done. We decided to choose three letters that were not used in Experiment 2 (mixed task) to avoid perseverations (i.e., letters D, O, and V).

Procedure

Participants were asked to type as many exemplars as possible for the semantic categories "fruits", "furniture" and "clothing", and the letter categories "D", "O", and "V". In verbal fluency tasks participants are usually given 60 seconds to give the highest number of responses as possible. However, in the present study participants were given five minutes for each semantic or letter category in order to increase the time period of possible answers and understand if the pattern of responses is maintained in a more extended time period. The presentation of the categories was alternated between semantic and letter fluency according to a Latin square design (12 lists – two participants per list). The software DMDX (Forster & Forster, 2003) was used for the presentation of the categories and data recording.

Results

In the semantic categories, exemplars belonging to a superordinate category (e.g., *clothes*) were considered correct answers except if subcategory exemplars were presented as well (e.g., *jacket, skirt,* etc.). If this happened, each subcategory exemplar was considered correct and not the superordinate exemplar. Responses were considered errors when there were perseverations (repetition of the same word), intrusions (words that did not belong to the category), and nonwords (incorrectly written words) and were excluded from the analyses (5.63% of the total number of answers). Moreover, all the proper names produced were excluded (5.35%) since the production of this type of words could be confounded with a cognate effect. Each exemplar was considered to be a cognate or noncognate according to the criteria explained in the Materials section.

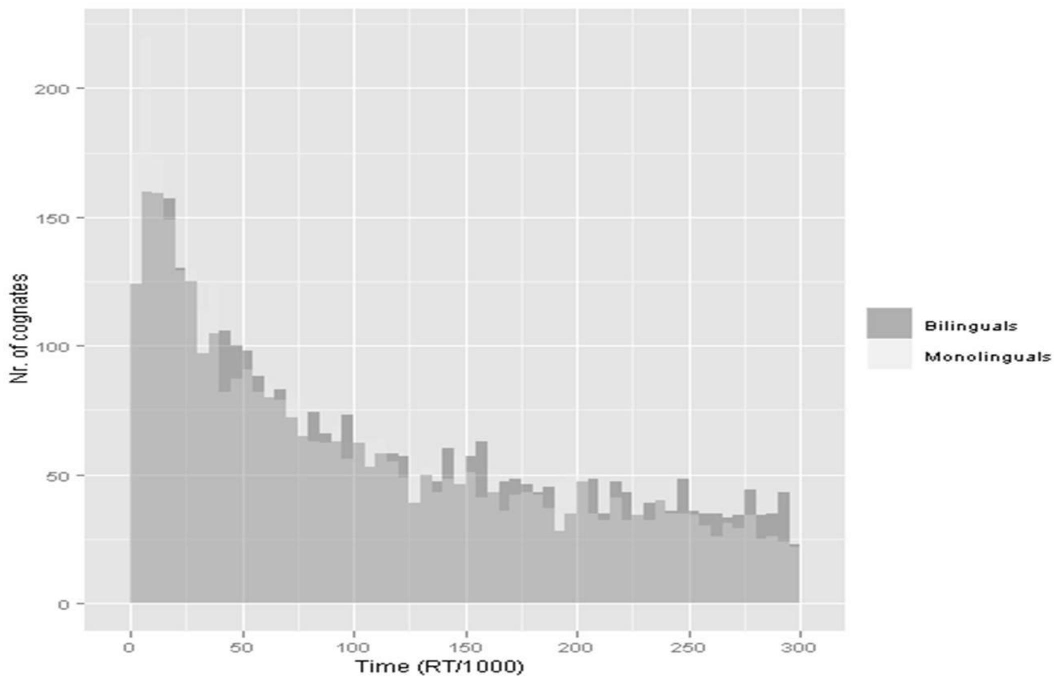

Figure 6. Distribution of responses of monolingual and bilingual participants in the verbal fluency task.

There was an average of sixteen answers per category, with a maximum of fifty-three answers and a minimum of one. Overall, monolinguals and bilinguals produced the same number of responses in the time given (see Figure 6 for an overview; monolinguals: 4013 responses; bilinguals: 3960 responses).

Responses containing cognates (monolinguals: 1732 trials; bilinguals: 1843 trials) were contrasted with noncognate responses (monolinguals: 2029 trials; bilinguals: 1936 trials) to accurately predict the probability of producing a cognate response. The logistic mixed-effects model included the predictors speaker group (bilinguals vs. monolinguals), task (semantic vs. letter category), and trial number (i.e., the order of production of each exemplar during the time available to respond). The odds of producing a cognate were significantly larger for bilinguals than monolinguals (see Figure 7). The effect of task was significant, meaning that the odds of producing a cognate were higher in the letter than semantic category task. The effect of trial was also significant, showing that the odds of producing a cognate decreased with an increasing order of trials. The interactions between speaker group and the other predictors were not significant. Statistical values for the significant predictors of cognate production are reported in Table 5.[5]

Table 5

Predictors of cognate production in the verbal fluency task

Predictor	β	SE β	z-value	p-value
Intercept	- 0.11	0.11	- 0.94	0.347
Speaker group	0.11	0.05	2.40	0.017
Task	0.72	0.15	4.71	<0.001
Trial	- 0.01	<0.01	- 5.35	<0.001

Note: SE = standard error

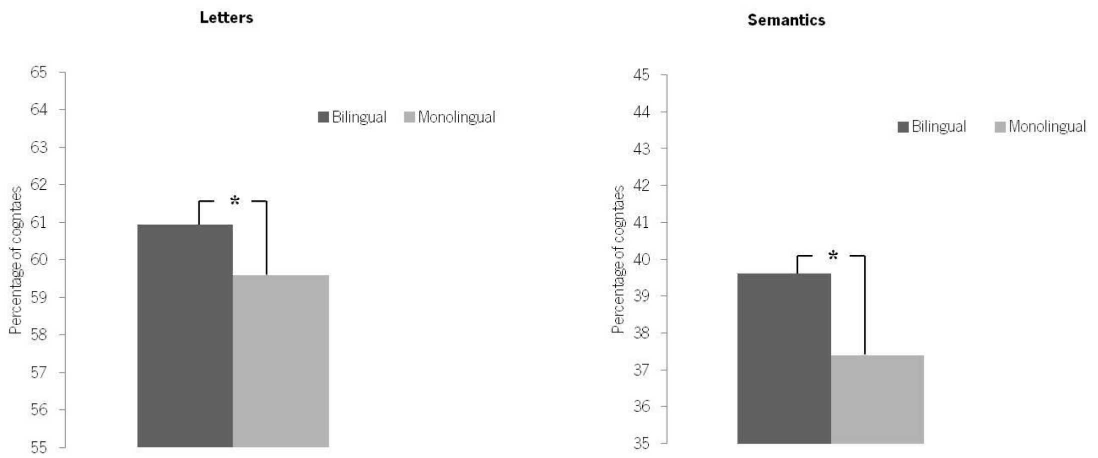

Figure 7. Percentage of cognate production for monolinguals and bilinguals in the semantic and letter category task

It is possible that the individual language usage characteristics of the bilinguals (taken from the Language History Questionnaire) could have influenced the present cognate effect. If these ratings would be predictive of the usage of cognate words, one could argue that cognate retrieval should vary

[5] Note that including individual by-random slopes into the logistic model did not improve the model's fit and thus we retained the model with simple by-participant and by-item intercept random slopes.

depending on the individual amount of French usage. For example, participants who at present do not have any French exposure at all could show a smaller cognate effect in the present task than participants who still have little exposure. Therefore, we added these values as predictors in the previous logistic mixed-effects model. In particular, we looked at the number of hours and percentage of time speaking in French and in EP, the participants' age, the years spent in France and in Portugal, and the context of learning L2 (at home, at school, or both). None of these variables were significant. Note, however, that our questionnaires were probably not detailed enough to obtain fine-grained measures for these variables. It remains to be established how such variables influence variability of the cognate effect at an individual level.

Experiment 2: Mixed task

Method

Participants

The participants in Experiment 2 were the same as in Experiment 1, with 24 EP-French bilinguals and 24 EP native monolinguals.

Materials

The mixed task consisted of individual trials of a semantic category together with a first letter (e.g., "ANIMAL: B"). For the nine semantic category translated to EP, we looked at the number of exemplars that could be elicited for each letter. Given that age of acquisition is one of the most influential predictors of lexical availability (Hernandez-Muñoz, Izura, & Ellis, 2006), the pairs of letters and categories were controlled for frequency and age of acquisition in EP (i.e., excluding very typical exemplars like "ANIMAL: C" – *cão* [dog]; Marques, Fonseca, Morais, & Pinto, 2007; Soares et al., in press). Overall, each combination of a semantic category and a letter had similar probabilities of generating cognates or noncognates (e.g, for the semantic category "animals" starting with the letter A, there were eight possible cognate candidates and eight possible noncognate candidates). A total of thirty trials were created with six semantic categories and a maximum of seven and a minimum of three letters per category. The selected categories were "animals" (32% of cognates), "musical instruments" (55% of cognates), "vegetables" (26% of cognates), "tools" (19% of cognates), "professions" (15% of cognates), and "vehicles" (38% of cognates). In Table 6, all the combinations of category and letter in the mixed task are presented.

Table 6:

Category and letter combinations in the mixed task

Letter	Animals	Musical Instruments	Vegetables	Tools	Professions	Vehicles
A	X				X	
B	X	X		X	X	X
C		X				
E	X				X	X
F		X			X	X
G					X	
I					X	
L				X		X
M	X			X		
N					X	
P			X			
R	X			X		
S		X	X			
T	X	X	X			X

Procedure

Each pair (category and letter) was presented for 30 seconds or until the participant finished writing his/her answer. The Mix program (van Casteren & Davis, 2006) was used to randomize the order of presentation, making sure categories and letters were appropriately spread out (minimal distance of two between the same category or the same letter), creating a different order for each participant (both bilinguals and monolinguals). The software DMDX (Forster & Forster, 2003) was used for the presentation of the categories and data recording.

Participants were asked to write down the first exemplar that came to their minds matching the required semantic and letter category. Participants were asked to answer as fast as possible while trying not to make mistakes.

Results

As in Experiment 1, we used a logistic mixed-effects model to explore the probability of cognate production in the mixed task. Responses containing cognates (monolinguals: 290 trials; bilinguals: 322 trials) were contrasted with noncognate responses (monolinguals: 261 trials; bilinguals: 225 trials) to accurately predict the probability of producing a cognate response. The model included the predictors speaker group (bilinguals vs. monolinguals) and trial number (i.e., the order of occurrence of a specific category). Results showed that the odds of producing a cognate were significantly larger for bilinguals than monolinguals (β = 0.33, *SE* = 0.13, *z* [1094] = 2.50, *p* = 0.013) (see Figure 8). After correcting for the proportion of possible cognate and noncognate responses for each semantic category, the effect of trial and the respective interaction with speaker group were not significant.[6]

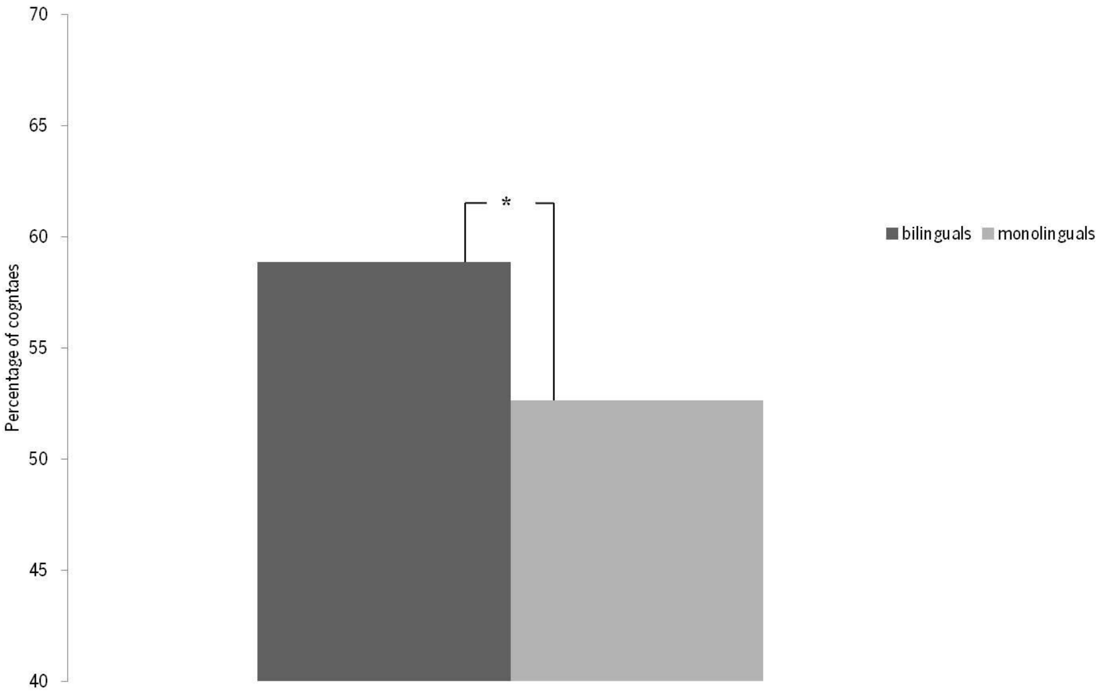

Figure 8. Percentage of cognate production for monolinguals and bilinguals in the mixed task

Similar to Experiment 1, the bilinguals' language history characteristics were not significant. Importantly, the effects reported for Experiment 2 confirm the pattern of results obtained in Experiment 1 and show in more detail that bilinguals retrieve more cognates than noncognates in verbal fluency tasks.

General Discussion

In the present study, two experiments explored monolinguals and bilingual (written) word production in a verbal fluency task to provide further insights about previously reported bilingual disadvantages in such kind of task. In Experiment 1, a standard verbal fluency task, participants were

[6] The linear mixed model was adjusted for the probability of cognate production for each category by introducing a weights function that accounted for the previously estimated cognate proportions per category (see Methods).

asked to respond to three semantic and three letter categories. Two methodological options were added in order to better control for the chances of bilingual cognate production in comparison with previous studies. On the one hand, the response time window of the task was increased, leaving participants five minutes instead of the standard time of 60 seconds. On the other hand, we conducted an a priori estimation of the proportion of cognate words for each semantic category. This allowed controlling for possible unequal proportions of cognates per category that could have been responsible for previously reported bilingual disadvantages. In Experiment 2, a more restricted verbal fluency task, participants were asked to retrieve a single exemplar that belonged to a semantic category and begun with a given letter. In this task again, each category pair could equally generate a cognate or a noncognate response.

Overall, monolinguals and bilinguals produced the same number of responses in the time given. Contrary to previous studies (Gollan et al., 2002, 2008; Rosselli et al., 2000; Sandoval et al., 2010), bilinguals did not present a "disadvantage" in the verbal fluency task. They did not produce a lower number of examplars when compared to monolinguals. Moreover, in this study the interaction between speaker group and task was not statistically significant. Therefore, bilinguals and monolinguals were not statistically different in the number of exemplars produced in semantic or letter categories. However, when considering the number of produced cognates, bilinguals named a significantly higher number of cognates than monolinguals in letter and semantic categories. Besides, bilinguals also produced more cognate words than monolinguals in the mixed experiment (i.e., Experiment 2). One possible explanation for the difference between semantic and letter categories found in previous studies was based on the idea that letter categories could allow for a higher number of cognate words than the semantic categories (Michael & Gollan, 2005). That is, in semantic categories, the number of cognates could be more limited than in letter categories. Thus, bilinguals could be forced to produce less cognate exemplars simply because they were not available. In previous studies on verbal fluency with bilinguals there is no information on the number of possible cognates to be produced per semantic categories. Therefore, it is possible that the differences between letter and semantic categories are caused by the number of cognates that the participants could (or could not) produce. The present study made an important step forward in tackling this problem by estimating cognate and noncognate distribution per semantic category. Moreover, the present results show that the odds to produce a cognate word were higher in the letter than in the semantic categories. It is possible that there is more influence of French in letter categories due to the higher number of words available than in semantic categories, where there are less available responses. In addition, participants had a larger time window to respond compared to previous studies that may have incited participants to produce more exemplars which in turn eliminated the difference between bilinguals and monolinguals. The restricted verbal fluency task of Experiment 2 replicates and confirms the pattern obtained in Experiment 1, in which bilinguals produced more cognate words than monolinguals when responding only with a single exemplar. This task was more demanding in terms of executive control and more controlled compared to the standard less restricted verbal fluency task.

The present work shows that the chosen methodological options in order to improve the chances to elicit cognate responses are worth exploring in future studies on bilingual verbal fluency tasks. However, the development of future studies with more balanced bilinguals in terms of frequency of use of each language is necessary since the bilingual participants tested in this study were switched-dominance bilinguals living in an exclusive monolingual environment. Nevertheless, results showed that bilinguals clearly differed from monolinguals in the number of cognate words produced in both tasks. Cognates are more resistant to language use decline (Schmid & de Bot, 2004), thus, the facilitation effect of cognate production can still emerge in a group that no longer uses a second language on a daily basis with the same frequency as in early childhood. Altogether, the present study emphasizes the role of cognate words in bilingual word production, in both restricted and unrestricted verbal fluency tasks.

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DISCUSSION

The present work was developed with the main aim to study the TOT phenomenon and its contribution to the further comprehension of the architecture and functioning of the speech production system in both monolingual and bilingual populations. Four different studies were presented. The first one presents EP norms for name agreement, concept familiarity, subjective frequency and visual complexity for 157 colored and tridimentional pictures. These variables, up to now unavailable for EP, are considered crucial in cognitive psychology because of their influence in picture processing (e.g., Alario et al, 2004; Cycowicz et al., 1997; Rossion & Pourtois, 2004; Sanfeliu & Fernandez, 1996). Indeed, they are particularly critical when considering naming latencies and memory processes in word retrieval and lexical access and, consequently, in TOT studies. Thus, this study enabled us to characterize a dataset that comprises a majority of pictures with relatively high name agreement and low subjective frequency, concept familiarity and visual complexity ratings. The correlations between the four evaluated variables were significant and globally in the same direction as the correlation analyses developed by previous similar studies (e.g., Alario & Ferrand, 1999; Bonin, Peereman, Malardier, Méot, & Chalard, 2003; Snodgrass & Vanderwart, 1980). These characteristics make the stimuli in the dataset particularly suitable for TOT states induction and resolution experiments. Nevertheless, it constitutes a relevant tool to other picture naming or recognition research in EP.

Based on this EP pictorial database, two experimental studies on TOT induction and resolution were then developed. The first study was performed by EP monolinguals whereas the second study was performed by EP-English bilinguals. In both studies, participants were asked to perform a picture naming task in order to induce TOT states. Then, with the purpose of exploring the role of phonological syllable position in TOT resolution, syllabic pseudohomophones related with the target word by the first or the last syllable were embedded in the pseudowords that formed the lexical decision task carried out after each picture. The target word length (in number of syllables) was also manipulated. Thus, in the first study conducted with EP monolinguals there were two, three, or four-syllable long target words and in the EP-English bilingual study, the target words were two and three-syllable long. In this second study conducted with bilinguals, no four-syllable long words were used because of their scarceness in English and due to the necessity to have words that in both languages (i.e., EP and English) presented similar lexical features (e.g., frequency, number of letters, number of syllables). Additionally, the cognate status (cognate vs. noncognate) of the target words was also considered (half of the target words were cognates and the other half were noncognates) in this latter study, due to the influence that this variable has in bilingual processing in general and in TOT states in particular. In fact, cognate words seem to facilitate speech production in bilinguals and particularly, to reduce the number of induced TOTs (Gollan & Acenas, 2004). Therefore, these two studies allowed us to explore the mechanisms that underlie TOT induction and resolution both in monolinguals and bilinguals. Interestingly, as the explored languages in the present work (EP and English) hold different characteristics regarding to their syllabic structure and definition of syllable boundaries, the present research contributes to the knowledge of what mechanisms underlying language representation and processing are consistent across languages or specific for each language structure.

In the monolingual study, results showed a significant syllabic pseudohomophone priming effect facilitating TOT resolution. Specifically, there was more TOT resolution when participants were primed by the last than by the first syllable, especially in four-syllable long words. The obtained results were not consistent with what had previously been observed in the literature, i.e., more TOT resolution for the first syllable position (Abrams et al., 2003; White & Abrams, 2002) probably because positional syllable frequency biased results in these previous studies. The main effect of word length was also significant as four-syllable long words produced not only more TOT induction but also more TOT resolution in comparison to three and two-syllable long words. The fact that longer words induced more TOTs was expected since they need to activate a larger number of nodes to be selected in comparison to shorter words (Mackay, 1987). However, the facilitation effect for longer words in TOT resolution was an unexpected and a more puzzling result. A possible explanation was presented, assuming that, when in TOT, longer words produce higher levels of activation than shorter words due to the larger number of nodes need to be activated to form the word (see Pitt & Samuel, 2006). This higher activation added to the activation provided by the phonological prime facilitates the retrieval of the phonological information and, consequently, incites more TOT resolution. Nonetheless, these results seem to support the idea that phonological syllable-sized units perform an important role in the process of lexical access and speech production, facilitating TOT resolution through the reinforcement of the phonological connections. Moreover, this study presents evidence establishing the syllable position and word length of the target word as relevant variables on TOT states resolution.

In the bilingual study, results showed that, as expected, bilinguals presented more TOTs than monolinguals. Moreover, bilinguals presented more TOTs in their L2 than in their L1, and more TOTs for noncognate words than for cognate words. These results are consistent with the weaker links hypothesis developed by Gollan and Acenas (2004). Because the strength of inter-level connections (i.e., between semantic and syntactic levels and the phonological level) depends essentially on the words' frequency and recency of use (Burke et al., 1991), bilinguals present more TOT states than monolinguals since they spend less time using words of each particular language. Besides, these connections seem to be especially weak in the less dominant (and consequently, less frequently used) language. Additionally, since cognate words share not only form but meaning across languages, their connections are strengthened and their lexical connections stronger. Consequently and as expected, cognate words were less prone to induce TOT states than noncognate words. Interestingly, when performing the task in EP, bilinguals showed more TOTs for three- than for two-syllable long words, result that was not obtained when performing the task in English. Since EP is a syllable-timed language with well-defined syllable boundaries, it seems that the effect of word length was highlighted when bilinguals were asked to respond in EP but not in English. The same pattern of results was obtained for the monolingual control group that performed the task exclusively in EP. Thus, the present results seem to suggest that the difference obtained between languages is due to different role of words' syllabic structure across languages, involving different mechanisms in lexical access and word retrieval.

Concerning TOT resolution, results showed that even though there were no differences between bilinguals and monolingual, bilinguals that were primed by the first syllable showed more TOT resolution than participants that did not receive any phonological priming and marginally more TOT resolution than participants primed by the last syllable. Nevertheless, this effect vanished when positional syllable frequency was considered in the analysis comparing bilinguals and monolinguals. Therefore, this result does not replicate the result obtained in the EP monolinguals study in which there was more TOT resolution when participants were primed by the last than by the first syllable. However, it is worth noting that in the monolingual study the advantage in TOT resolution was restricted to four-syllable long words. In the bilingual study and for the reasons afore mentioned the targets were only two- and three-syllables long, which may be responsible for the differences obtained in these studies. Nevertheless, the presented studies challenge the established idea in the literature that the first syllable is more important for the retrieval of the word in TOT (Abrams et al., 2003). It seems that the syllable position priming in TOT resolution cannot be considered in isolation from positional syllable frequency. Future studies that control and consider both variables in parallel are demanded in order to clarify the influence of syllable position in TOT resolution. When considering the cognate status effect in TOT resolution, it was showed that it interacted not only with the word length but also with the language used. In fact, three-syllable long cognate words showed more TOT resolution than two-syllable long cognate words and more TOT resolution tends to be found for cognate words in English than in EP. Due to their shared connections, cognate words might allow a higher contact between languages integrating information from both languages to facilitate the phonological retrieval of the word in TOT. In particular, they may rely on the structural characteristics of the languages especially when one of the languages has more defined syllable boundaries than the other. Being English the less frequently used language of this group of bilinguals, it seems that the phonological features shared with L1 allowed them to facilitate TOT resolution in their less used language.

In sum, this study showed that phonologically related primes (in this case, syllabically) facilitated TOT resolution, even though the role of syllable position is still controversial. The provided evidence points out to the importance of considering simultaneously the syllable position and the positional syllable frequency in order to clearly determine which segment of the word is more relevant in TOT resolution. Moreover, the word length has determined its relevance in TOT induction particularly when considering a syllable-timed language, for which there were more TOT states in longer than in shorter target words. Finally, the word length and the language in use showed to interact with the cognate status of the word in TOT resolution, considering that these words may rely on the structural characteristics of the languages to facilitate word retrieval and TOT resolution. Thus, the present work has helped establishing the cognate status as one of the most important variables to be considered in bilingual speech production tasks.

In order to further explore the production of cognate words in bilingual speech production, the fourth and last presented study was developed, focusing on a different production task (i.e., the verbal fluency task). In this study, two different (typing) tasks were performed. In a first task, EP-French bilinguals were asked to give a maximal number of exemplars belonging to a given semantic or letter category, according to a more standard verbal fluency procedure. The time-period to respond in this task was enlarged to five minutes instead of the standard 60 seconds usually used. In the second task, participants were asked to produce one single exemplar belonging simultaneously to a semantic and letter category. The estimation of the maximum number of cognates that could be generated in the used semantic categories allowed us to control for a priori unequal proportions of cognates per category. Results on the two fluency tasks showed that, contrary to previous studies (Gollan et al., 2002, 2008; Rosselli et al., 2000; Sandoval et al., 2010), bilinguals did not produce a lower number of exemplars when compared to monolinguals. Moreover, in the first task, bilinguals and monolinguals were not statistically different in the number of exemplars produced in semantic or letter categories. In fact, bilinguals named a significantly higher number of cognates than monolinguals in letter and semantic categories and in both presented tasks. Thus, the present work shows that the methodological options in order to improve the chances to elicit cognate responses are worth exploring in future studies on bilingual verbal fluency tasks. Specially, this study allowed to better understand the processes of the bilingual production system and particularly, the extent in which cognate status production facilitate bilinguals' performance.

Overall, the present work reinforces the importance of the development of bilingual studies for the growth of psycholinguistic research and of the knowledge on the language production system in particular. The study of the TOT phenomenon is considered a great opportunity to carefully explore the mechanisms operating in speech production. This “failure” in the normal process of producing a familiar word enables us to understand the way the information necessary to form a word is stored, accessed and retrieved. Furthermore, its study in bilingual populations adds a new cross-linguistic perspective that highlights the importance of the structure of the language in use and the shared connections across languages not only in TOT induction but also in its resolution. The role of syllabic variables as the number of syllables or syllable position are then worth exploring in future research in languages with different syllabic structures, providing more insight on the language production system.

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APPENDICES

APPENDIX A

European Portuguese norms for 157 pictures

Picture number	Modal name	Know	DK	DR	NA		Subj. Freq.		Familiarity		VC		Different answers	Letters	Syllables	Freq. P_Pal	Semantic Category
					H	%	M	SD	M	SD	M	SD					
1	fada/fairy	89,42	7,69	2,88	4,41	0,29	2,04	1,06	2,70	1,32	3,19	0,92	35,00	4	2	1,44	fantasy
2	trolha/handyman	53,47	18,81	27,72	3,68	0,17	2,89	1,62	3,67	1,00	2,67	1,12	31,00	6	2	0,77	profession
3	bazuca/bazooka	17,43	59,63	22,94	3,51	0,21	2,00	0,82	2,00	0,82	3,75	0,96	12,00	6	3	0,09	weapon
4	albino/albino	83,33	8,82	7,84	3,30	0,25	1,43	0,51	2,00	1,00	3,33	1,11	16,00	6	3	1,01	personal traits
5	groselha/cranberry	58,43	13,48	28,09	3,25	0,21	1,91	0,70	2,73	1,35	2,09	0,83	14,00	8	3	0,15	fruits and vegetables
6	tijolo/brick	86,96	6,52	6,52	3,19	0,33	2,90	1,38	3,45	1,37	2,38	1,19	31,00	6	3	1,01	tool
7	furacão/hurricane	64,81	10,19	25,00	3,17	0,27	2,11	1,24	2,53	1,31	3,05	1,27	17,00	7	3	2,69	nature
8	ramo de flores/bouquet	97,98	0,00	2,02	3,02	0,23	2,86	1,13	3,23	1,11	3,00	1,27	11,00				flowers
9	guitarra portuguesa/portuguese guitar	75,49	3,92	20,59	2,83	0,39	2,07	1,11	2,90	1,24	3,10	1,37	10,00				music
10	ramo de flores/bouquet	98,99	0,00	1,01	2,68	0,34	2,88	1,02	3,45	1,15	2,45	1,44	9,00				flowers
11	bolhas/bubbles	95,92	3,06	1,02	2,68	0,43	2,50	1,20	3,25	1,32	2,13	1,40	12,00	6	2	1,10	nature
12	carta/card	98,11	1,89	0,00	2,60	0,34	3,43	1,04	3,86	1,09	2,20	1,23	10,00	5	2	126,20	tool
13	bandolim/mandolin	65,91	4,55	29,55	2,33	0,34	2,20	1,11	2,85	1,18	3,00	1,08	7,00	8	3	1,14	music
14	chaise longue/chaise longue	75,73	2,91	21,36	2,17	0,32	2,08	1,26	2,44	1,33	2,72	1,31	7,00				furniture
15	televisão/television	98,18	0,00	1,82	2,16	0,53	4,63	0,75	4,72	0,56	2,25	1,23	7,00	9	4	213,96	furniture
16	bilhar/snooker	92,86	3,57	3,57	2,14	0,60	2,61	1,21	3,18	1,29	2,81	1,20	12,00	6	2	2,67	games
17	bazuca/bazooka	24,76	62,86	12,38	2,12	0,46	1,17	0,39	1,83	1,11	2,92	1,16	7,00	6	3	0,09	weapon
18	monitor/monitor	100,00	0,00	0,00	2,12	0,45	4,42	0,94	4,58	0,79	2,31	1,21	6,00	7	3	4,10	furniture
19	cascata/waterfall	88,17	1,08	10,75	2,07	0,44	1,92	0,94	2,31	1,26	3,44	1,18	5,00	7	3	2,70	nature
20	grelhador/barbecue	93,14	0,98	5,88	2,06	0,55	3,25	0,99	3,67	1,17	2,58	1,11	6,00	9	3	0,19	furniture
21	mágico/magician	91,82	6,36	1,82	1,99	0,51	2,13	1,12	2,75	1,37	3,29	1,39	7,00	6	3	7,62	profession
22	avelã/hazelnut	96,26	1,87	1,87	1,97	0,48	2,88	1,22	3,45	1,32	2,35	0,95	8,00	5	3	0,14	fruits and vegetables
23	castiçal/candlestick	74,31	7,34	18,35	1,94	0,52	2,33	1,30	3,17	1,38	2,26	1,01	9,00	8	3	0,19	furniture
24	alecrim/rosemary	49,52	19,05	31,43	1,92	0,63	3,09	1,13	3,79	1,08	2,76	1,17	8,00	7	3	0,97	fruits and vegetables
25	melão/melon	96,11	1,56	2,33	1,91	0,38	3,53	1,15	4,02	1,06	2,24	1,00	9,00	5	2	1,99	fruits and

Picture number	Modal name	Know	DK	DR	NA H	NA %	Subj. Freq. M	Subj. Freq. SD	Familiarity M	Familiarity SD	VC M	VC SD	Different answers	Letters	Syllables	Freq. P_Pal	Semantic Category
																	vegetables
26	esquimós/eskimos	88,12	3,96	7,92	1,82	0,67	1,58	0,79	2,23	1,21	3,57	1,29	10,00	8	3	0,41	personal traits
27	pêndulo/pendulum	47,37	29,47	23,16	1,80	0,56	1,40	0,50	2,12	0,97	1,36	1,78	5,00	7	3	0,72	tool
28	catedral/cathedral	65,57	11,48	22,95	1,78	0,65	2,60	1,07	3,10	1,18	4,21	1,29	9,00	8	3	8,73	building
29	balas/bullets	95,00	1,00	4,00	1,78	0,63	2,03	1,21	2,70	1,44	2,05	1,08	8,00	5	2	8,59	weapon
30	catedral/cathedral	75,79	8,42	15,79	1,78	0,64	2,74	1,16	3,24	1,34	3,96	1,26	9,00	8	3	8,73	building
31	seringa/syringe	98,97	0,00	1,03	1,78	0,55	2,40	1,10	3,28	1,31	2,38	1,08	5,00	7	3	2,97	tool
32	vinagre/vinager	88,35	2,91	8,74	1,77	0,55	3,82	1,12	4,22	0,93	2,00	1,09	8,00	7	3	2,34	food
33	vampiro/vampire	94,07	4,24	1,69	1,74	0,63	2,01	1,28	2,43	1,35	2,97	1,29	12,00	7	3	1,15	fantasy
34	edredon/comforter	95,15	0,00	4,85	1,73	0,59	4,17	1,01	4,41	0,80	1,81	0,95	6,00				furniture
35	seringa/syringe	95,79	2,11	2,11	1,72	0,55	2,54	1,20	3,24	1,10	2,80	1,05	5,00	7	3	2,97	tool
36	tornado/tornado	94,55	0,91	4,55	1,71	0,62	1,75	1,07	2,17	1,39	3,00	1,37	7,00	7	3	16,51	nature
37	fuso/spindle	35,93	25,45	38,62	1,69	0,50	1,55	0,95	2,08	1,21	2,32	1,05	9,00	4	2	0,88	tool
38	colibri/hummingbird	82,35	4,90	12,75	1,68	0,44	1,51	0,80	2,19	1,20	3,70	1,15	4,00	7	3	0,53	animal
39	tiara/tiara	91,26	3,88	4,85	1,63	0,66	1,35	0,63	1,73	0,99	2,95	1,17	6,00	5	3	0,04	accessory
40	mosca/fly	77,57	7,48	14,95	1,61	0,61	3,59	1,19	3,65	1,18	3,55	1,24	9,00	5	2	2,13	animal
41	alforreca/jellyfish	78,50	3,74	17,76	1,59	0,45	1,74	1,03	2,37	1,26	3,32	1,36	3,00	9	4	0,10	animal
42	mosquito/mosquito	84,85	3,03	12,12	1,58	0,56	3,38	1,23	3,77	1,03	2,17	1,15	6,00	8	3	1,23	animal
43	iguana/iguana	75,49	6,72	17,79	1,55	0,63	1,83	1,05	2,29	1,23	3,31	1,11	6,00	6	3	0,12	animal
44	flor/flower	72,44	7,87	19,69	1,55	0,75	3,74	1,16	4,04	1,08	2,71	1,16	10,00	4	1	13,33	flowers
45	iguana/iguana	78,38	5,41	16,22	1,54	0,65	1,67	0,94	2,23	1,25	3,18	1,11	6,00	6	3	0,12	animal
46	amoras/blackberries	89,92	3,36	6,72	1,54	0,53	2,63	1,19	3,39	1,31	2,26	0,99	6,00	6	3	0,50	fruits and vegetables
47	pêssego/peach	96,94	0,00	3,06	1,53	0,51	3,69	0,93	4,19	1,00	1,92	1,05	4,00	7	3	0,65	fruits and vegetables
48	coche/carriage	93,40	0,94	5,66	1,53	0,65	1,56	0,77	2,34	1,21	3,64	1,40	5,00	5	2	0,85	transport
49	nabos/turnip	94,59	0,90	4,50	1,52	0,46	3,35	1,06	3,71	1,25	2,10	1,12	5,00	5	2	0,64	fruits and vegetables

Picture number	Modal name	Know	DK	DR	NA		Subj. Freq.		Familiarity		VC		Different answers	Letters	Syllables	Freq. P_Pal	Semantic Category
					H	%	M	SD	M	SD	M	SD					
50	alcofa/baby carriage	69,83	6,03	24,14	1,45	0,54	2,75	1,46	3,73	1,34	2,41	1,23	6,00	6	3	0,20	transport
51	pássaro/bird	73,27	8,91	17,82	1,45	0,77	3,63	1,08	3,93	0,98	2,86	1,14	9,00	7	3	3,97	animal
52	barril/barrel	98,99	1,01	0,00	1,42	0,58	2,14	1,17	2,79	1,39	1,81	0,97	3,00	6	2	3,91	furniture
53	chita/cheetah	91,18	2,94	5,88	1,37	0,58	1,78	0,88	2,70	1,30	3,22	1,31	4,00	5	2	0,62	animal
54	selim/saddle	92,52	1,97	5,51	1,34	0,49	2,75	1,27	3,64	1,13	2,04	0,92	3,00	5	2	0,31	tool
55	banjo/banjo	46,81	24,47	28,72	1,33	0,67	1,69	0,89	2,24	1,27	3,03	1,02	4,00	5	2	0,45	music
56	salsichas/sausages	93,94	1,01	5,05	1,31	0,61	3,21	1,06	3,70	1,16	1,93	1,00	6,00	9	3	1,12	food
57	procissão/procession	63,83	13,83	22,34	1,29	0,80	2,27	1,07	3,19	1,32	3,75	0,96	8,00	9	3	10,17	religion
58	procissão/procession	78,76	7,08	14,16	1,29	0,89	2,59	1,07	3,46	1,32	3,82	0,96	8,00	9	3	10,17	religion
59	búfalo/buffalo	87,10	12,90	0,00	1,28	0,71	1,52	0,91	2,08	1,30	3,05	1,10	5,00	6	3	0,53	animal
60	cama/bed	80,37	5,61	14,02	1,27	0,77	4,58	0,98	4,68	0,79	2,74	1,19	6,00	4	2	25,02	furniture
61	guizo/bell	82,91	7,69	9,40	1,27	0,75	1,90	1,04	2,75	1,31	2,22	0,96	6,00	5	2	0,11	tool
62	revólver/revolver	100,00	0,00	0,00	1,26	0,49	1,68	1,08	2,42	1,40	2,84	1,09	4,00	8	3	2,67	weapon
63	coador/colander	90,00	3,00	7,00	1,25	0,72	3,63	1,14	4,08	1,08	2,11	1,12	4,00	6	2	0,05	tool
64	fole/bellows	41,76	5,49	52,75	1,25	0,79	1,97	1,07	2,47	1,31	2,50	0,90	6,00	4	2	0,47	tool
65	ostra/oyster	92,16	2,94	4,90	1,24	0,73	1,83	0,84	2,59	1,28	2,93	1,08	3,00	5	2	0,29	animal
66	queque/muffin	95,77	1,54	2,69	1,23	0,74	3,01	1,17	3,84	1,20	1,94	1,01	6,00	6	2	0,22	food
67	cinta/girdle	72,97	9,01	18,02	1,20	0,79	1,81	1,01	2,47	1,23	2,00	0,87	7,00	5	2	2,80	clothes
68	insecto/insect	28,43	43,14	28,43	1,20	0,79	2,91	1,08	3,13	1,18	3,52	1,27	5,00	7	3	1,60	animal
69	pilão/pestle	62,39	5,50	32,11	1,16	0,79	2,06	1,37	2,83	1,27	1,85	1,00	7,00	5	2	0,15	tool
70	couve/cabbage	95,60	1,10	3,30	1,15	0,70	3,80	1,05	4,10	1,01	2,56	1,18	2,00	5	2	1,57	fruits and vegetables
71	gôndola/gondola	84,47	0,97	14,56	1,14	0,80	1,67	0,86	2,31	1,15	2,94	1,20	6,00	7	3	0,18	transport
72	pedal/pedal	37,76	39,80	22,45	1,09	0,78	2,21	1,26	2,66	1,45	3,07	1,25	4,00	5	2	1,11	tool
73	prisma/prism	68,63	18,63	12,75	1,09	0,84	1,61	0,89	2,61	1,27	2,80	1,32	8,00	6	2	2,05	tool
74	alga/seaweed	93,55	2,15	4,30	1,06	0,68	2,54	1,09	3,27	1,22	2,51	1,10	2,00	4	2	0,55	animal
75	bróculos/broccoli	99,05	0,00	0,95	1,06	0,56	3,72	1,27	3,88	1,30	2,38	1,34	4,00	8	3	0,37	fruits and vegetables

Picture number	Modal name	Know	DK	DR	NA H	NA %	Subj. Freq. M	Subj. Freq. SD	Familiarity M	Familiarity SD	VC M	VC SD	Different answers	Letters	Syllables	Freq. P_Pal	Semantic Category
76	seta/arrow	96,12	0,97	2,91	1,05	0,59	2,12	1,29	2,90	1,49	1,86	1,05	2,00	4	2	1,69	weapon
77	hélice/propeller	79,61	0,97	19,42	1,03	0,77	2,22	1,16	2,60	1,28	1,76	0,96	3,00	6	3	0,85	tool
78	sapatos/shoes	100,00	0,00	0,00	1,03	0,91	4,66	0,64	4,69	0,70	2,01	0,99	3,00	7	3	12,82	clothes
79	gaivota/seagull	91,96	1,79	6,25	1,00	0,83	3,08	1,27	3,53	1,25	2,59	0,97	5,00	7	3	0,88	animal
80	águia/eagle	98,13	0,00	1,87	0,96	0,84	2,45	1,20	2,99	1,29	3,45	1,27	6,00	5	2	4,44	animal
81	girassol/sunflower	96,55	0,86	2,59	0,95	0,84	2,73	1,18	3,41	1,23	2,49	1,29	4,00	8	3	1,78	flowers
82	batatas/potatoes	98,98	0,00	1,02	0,94	0,64	4,40	0,76	4,50	0,74	1,73	1,04	1,00	7	3	9,19	fruits and vegetables
83	dálmata/dalmatian	100,00	0,00	0,00	0,94	0,65	2,58	1,24	3,19	1,33	2,74	1,14	1,00	7	3	0,15	animal
84	maca/stretcher	98,98	0,00	1,02	0,90	0,87	2,42	1,34	3,05	1,34	2,76	1,13	3,00	4	2	1,49	furniture
85	lasanha/lasagna	87,74	7,55	4,72	0,90	0,86	3,13	1,01	3,85	0,98	3,15	1,07	6,00	7	3	0,12	food
86	toalha/tablecloth	98,17	0,00	1,83	0,90	0,77	4,46	0,93	4,62	0,83	2,02	0,97	3,00	6	3	3,34	furniture
87	flamingo/flamingo	90,00	0,00	10,00	0,89	0,86	1,68	0,97	2,52	1,27	2,87	1,15	5,00	8	3	0,15	animal
88	acordeão/accordion	97,06	0,98	1,96	0,84	0,79	2,24	1,29	2,76	1,31	3,36	1,29	2,00	8	3	3,33	music
89	gorila/gorilla	97,03	0,00	2,97	0,84	0,85	1,86	0,95	2,70	1,29	3,04	1,31	4,00	6	3	0,58	animal
90	foice/sickle	91,38	0,86	7,76	0,82	0,88	1,66	0,80	2,55	1,30	1,72	0,83	6,00	5	2	4,29	tool
91	pedais/pedal	97,94	0,00	2,06	0,79	0,84	4,15	1,21	4,31	1,13	2,60	1,19	4,00	6	2	0,78	tool
92	fada/fairy	92,39	3,26	4,35	0,77	0,87	2,09	0,97	2,95	1,16	2,58	1,15	5,00	4	2	1,44	fantasy
93	nabo/turnip	88,14	0,85	11,02	0,76	0,88	3,20	1,15	3,74	1,12	1,91	1,03	5,00	4	2	0,52	fruits and vegetables
94	cantil/canteen	79,00	2,00	19,00	0,75	0,90	2,30	1,07	3,38	1,32	2,55	1,18	7,00	6	2	0,22	tool
95	colar/necklace	99,04	0,00	0,96	0,73	0,84	3,13	1,42	3,75	1,19	2,25	1,14	3,00	5	2	5,32	accessory
96	canela/cinnamon	100,00	0,00	0,00	0,73	0,87	3,51	1,19	3,85	1,14	2,12	1,05	3,00	6	3	1,62	food
97	toureiro/matador	90,00	1,00	9,00	0,68	0,91	1,96	1,07	2,45	1,32	2,87	1,33	7,00	8	3	3,11	profession
98	lobo/wolf	99,05	0,00	0,95	0,67	0,87	2,24	1,17	2,92	1,28	2,93	1,15	3,00	4	2	5,04	animal
99	ananás/pineapple	100,00	0,00	0,00	0,67	0,83	3,68	1,15	4,17	1,04	2,69	1,35	1,00	6	3	0,97	fruits and vegetables
100	castor/beaver	85,98	3,74	10,28	0,67	0,91	1,62	0,89	2,10	1,10	3,06	1,25	7,00	6	2	0,30	animal

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101	pepino/cucumber	96,26	0,93	2,80	0,65	0,83	3,52	1,12	3,97	1,03	2,03	1,05	1,00	6	3	0,58	fruits and vegetables
102	pódio/podium	85,83	5,00	9,17	0,62	0,84	2,33	1,11	3,09	1,29	1,78	0,89	1,00	5	2	9,17	furniture
103	tripé/tripod	86,51	5,95	7,54	0,62	0,91	2,35	1,13	2,90	1,23	2,10	0,90	6,00	5	2	0,57	tool
104	leme/weel	72,04	2,15	25,81	0,61	0,91	1,70	0,97	2,41	1,42	2,31	1,09	4,00	4	2	4,49	tool
105	papaia/papaya	85,09	2,63	12,28	0,59	0,92	2,69	1,19	3,09	1,30	2,30	1,08	5,00	6	3	0,15	fruits and vegetables
106	melão/melon	99,61	0,39	0,00	0,55	0,91	3,48	1,25	4,20	1,08	1,87	1,05	3,00	5	2	1,99	fruits and vegetables
107	biquini/bikini	98,02	0,99	0,99	0,53	0,91	3,41	1,24	4,10	0,99	2,14	1,10	3,00	6	3	0,15	clothes
108	dominó/domino	97,32	0,00	2,68	0,52	0,92	2,52	1,19	3,56	1,35	2,39	1,18	3,00	6	3	1,34	games
109	trampolim/trampoline	87,01	1,81	11,18	0,51	0,93	2,19	1,11	2,83	1,28	2,38	0,94	8,00	9	3	2,22	furniture
110	íman/magnet	93,40	0,00	6,60	0,47	0,94	2,17	1,09	2,92	1,32	1,58	0,85	5,00	4	2	0,88	tool
111	hiena/hyena	85,03	4,19	10,78	0,45	0,95	1,68	0,95	2,34	1,24	2,84	1,08	9,00	5	3	0,98	animal
112	panda/panda	97,73	1,14	1,14	0,41	0,93	2,19	1,29	2,79	1,35	2,64	1,13	2,00	5	2	0,27	animal
113	pudim/flan	97,80	0,00	2,20	0,40	0,94	3,01	1,20	3,61	1,18	1,98	0,85	3,00	5	2	1,21	food
114	garrafão/demijohn	96,08	1,96	1,96	0,39	0,95	2,81	1,38	3,46	1,36	2,33	1,14	4,00	8	3	1,01	tool
115	túnel/tunnel	93,00	1,00	6,00	0,38	0,95	3,07	1,16	3,51	1,13	3,23	1,26	3,00	5	2	21,15	transport
116	esquadro/triangle	94,22	1,52	4,26	0,37	0,95	2,77	1,31	3,50	1,27	1,94	0,96	6,00	8	3	0,53	tool
117	ábaco/abacus	39,56	8,79	51,65	0,37	0,94	1,82	0,97	2,85	1,21	2,41	1,13	1,00	5	3	0,13	games
118	puzzle/jigsaw puzzle	100,00	0,00	0,00	0,35	0,93	3,12	1,21	3,68	1,11	2,45	1,21	1,00	6	2	3,33	games
119	cilindro/cylinder	92,63	1,05	6,32	0,33	0,95	2,77	1,30	3,18	1,23	1,38	0,66	3,00	8	3	2,35	tool
120	fogão/oven	98,02	1,98	0,00	0,33	0,94	4,59	0,74	4,71	0,60	2,71	1,28	1,00	5	2	2,65	furniture
121	pepino/cucumber	98,10	0,95	0,95	0,32	0,94	3,30	1,27	3,96	1,16	1,65	0,96	1,00	6	3	0,58	fruits and vegetables
122	brincos/earrings	98,97	1,03	0,00	0,31	0,96	3,66	1,46	4,20	1,11	2,08	1,12	3,00	7	2	2,07	accessory
123	tigre/tiger	99,11	0,30	0,59	0,29	0,96	2,25	1,20	2,86	1,37	3,00	1,27	2,00	5	2	2,97	animal
124	cacto/cactus	97,30	0,90	1,80	0,26	0,96	2,57	1,17	3,18	1,28	2,48	1,15	2,00	5	2	0,26	flowers
125	boina/beret	90,20	8,82	0,98	0,24	0,97	2,56	1,29	3,30	1,31	1,72	0,83	2,00	5	2	1,33	accessory

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126	caixão/coffin	98,00	1,00	1,00	0,23	0,97	2,01	1,07	2,87	1,39	2,45	1,19	2,00	6	2	4,03	furniture
127	fisga/slingshot	92,55	1,06	6,38	0,18	0,98	2,08	1,00	3,05	1,40	1,84	0,96	2,00	5	2	0,29	tool
128	baton/lipstick	96,69	1,65	1,65	0,17	0,97	3,00	1,41	3,72	1,41	2,00	0,94	1,00	5	2	0,08	accessory
129	luvas/mittens	98,95	0,00	1,05	0,17	0,98	3,54	1,19	4,10	1,01	1,93	1,03	2,00	5	2	7,22	accessory
130	gorro/beanie	97,73	1,14	1,14	0,09	0,99	3,40	1,27	3,92	1,19	1,96	1,04	1,00	5	2	0,62	accessory
131	mola/clothespeg	97,92	0,00	2,08	0,08	0,99	4,09	1,06	4,38	0,93	1,92	1,02	1,00	4	2	1,98	tool
132	antena/antenna	94,29	3,81	1,90	0,08	0,99	2,68	1,31	3,17	1,32	2,53	1,02	1,00	6	3	29,62	furniture
133	triciclo/tricycle	98,08	0,00	1,92	0,08	0,99	2,41	1,12	3,43	1,35	2,50	1,13	1,00	8	3	0,41	transport
134	pavão/peacock	94,92	0,78	4,30	0,07	0,99	2,04	1,11	2,90	1,35	3,49	1,30	1,00	5	2	0,60	animal
135	manga/mango	90,82	3,06	6,12	0,00	1,00	3,63	1,10	3,91	1,07	1,71	0,83	0,00	5	2	5,46	fruits and vegetables
136	coala/koala	95,00	0,00	5,00	0,00	1,00	1,68	0,76	2,40	1,33	2,92	1,25	0,00	5	3	0,06	animal
137	funil/funnel	95,28	1,89	2,83	0,00	1,00	2,92	1,33	3,72	1,28	1,43	0,82	0,00	5	2	0,87	tool
138	canhão/cannon	96,23	0,00	3,77	0,00	1,00	1,73	0,86	2,48	1,30	2,89	1,14	0,00	6	2	3,00	weapon
139	dragão/dragon	96,67	0,00	3,33	0,00	1,00	2,48	1,44	3,00	1,46	3,30	1,38	0,00	6	2	3,04	fantasy
140	dedal/thimble	97,09	1,94	0,97	0,00	1,00	2,06	1,09	2,97	1,40	2,09	1,07	0,00	5	2	0,18	tool
141	tampão/tampon	97,30	1,80	0,90	0,00	1,00	3,07	1,46	3,79	1,33	1,73	0,92	0,00	6	2	1,23	tool
142	canguru/kangaroo	97,78	2,22	0,00	0,00	1,00	1,70	1,01	2,42	1,31	2,84	1,21	0,00	7	3	0,44	animal
143	balde/bucket	97,92	1,04	1,04	0,00	1,00	3,52	1,19	3,90	1,16	1,71	0,86	0,00	5	2	3,43	tool
144	pinguim/penguin	98,80	0,60	0,60	0,00	1,00	2,23	1,17	2,90	1,35	2,33	1,03	0,00	7	2	0,24	animal
145	morango/strawberry	98,97	1,03	0,00	0,00	1,00	3,82	1,01	4,26	0,95	2,14	1,08	0,00	7	3	0,72	fruits and vegetables
146	pinça/tweezers	98,99	1,01	0,00	0,00	1,00	3,66	1,35	4,02	1,17	1,89	0,98	0,00	5	2	0,42	tool
147	varanda/balcony	99,08	0,00	0,92	0,00	1,00	3,98	1,06	4,37	0,93	2,63	1,12	0,00	7	3	6,51	furniture
148	tractor/tractor	99,11	0,00	0,89	0,00	1,00	2,05	1,09	2,82	1,37	3,20	1,32	0,00	7	2	2,58	transport
149	balão/balloon	100,00	0,00	0,00	0,00	1,00	3,10	1,23	3,71	1,29	1,37	0,71	0,00	5	2	7,02	games
150	banana/banana	100,00	0,00	0,00	0,00	1,00	4,36	0,92	4,56	0,88	1,47	0,75	0,00	6	3	3,33	fruits and vegetables

Picture number	Modal name	Know	DK	DR	NA H	NA %	Subj. Freq. M	Subj. Freq. SD	Familiarity M	Familiarity SD	VC M	VC SD	Different answers	Letters	Syllables	Freq. P_Pal	Semantic Category
151	colchão/mattress	100,00	0,00	0,00	0,00	1,00	4,44	0,97	4,51	0,93	1,78	0,98	0,00	7	2	2,05	furniture
152	farol/lighthouse	100,00	0,00	0,00	0,00	1,00	2,34	1,09	3,17	1,30	2,75	1,18	0,00	5	2	4,09	building
153	kiwi/kiwi	100,00	0,00	0,00	0,00	1,00	3,74	1,06	4,16	0,98	2,17	1,21	0,00	4	2	0,56	fruits and vegetables
154	lareira/fireplace	100,00	0,00	0,00	0,00	1,00	3,31	1,22	3,92	1,17	2,43	1,11	0,00	7	3	3,33	furniture
155	pijama/pyjamas	100,00	0,00	0,00	0,00	1,00	4,58	0,83	4,61	0,78	2,41	1,08	0,00	6	3	1,18	clothes
156	régua/ruler	100,00	0,00	0,00	0,00	1,00	3,69	1,18	4,20	1,04	1,48	0,90	0,00	5	2	6,09	tool
157	zebra/zebra	100,00	0,00	0,00	0,00	1,00	2,01	0,99	2,94	1,37	2,68	1,34	0,00	5	2	0,32	animal

APPENDIX B

Target words and syllabic pseudohomophones for European Portuguese monolingual TOT study

Target	First syllable primes				Last syllable primes			
grelha	grefar	grenol	grameijo	grepentisal	prilha	taselha	torpolha	salha
tear	tená	tepo	tiprera	titarcano	contemari	tribaro	riar	prictar
dedal	derra	devom	deterar	demarsero	trodal	ridal	sitenidal	cramadal
pincel	pintro	pimpota	pimbrano	pintri	crissel	tranecel	malinacel	cassel
foice	foimá	foitraro	foilimabo	foita	crasse	chisce	trampece	monase
tenaz	tessamar	tenhe	teba	tepomir	pintonaz	justinás	ernaz	ninás
fuso	fumolho	futangue	funã	fupe	jonsole	jiso	caremuzo	tranzo
urna	urto	urzifime	urtome	urpu	fona	binjona	tréna	guistena
anzol	ambonona	angortir	ansis	ampo	sisol	tospesol	croizol	penibuzol
busto	buscama	buspotim	busma	busve	medimato	cronitu	sasto	quetu
íman	itapuna	ilostipo	ivim	ibor	creman	posman	tripatoman	crupaman
romã	rubinas	roveria	rone	rupo	tremã	tamã	chonemã	susipomã
tripé	tripostiar	triminos	tribão	trite	cranepé	nospé	labemapé	relpé
jante	jampolta	jamboapir	jantra	jãpro	crate	fuite	poloite	sastrimote
termo	terpobana	terte	terla	terbina	jombomu	guelotamo	gremu	brimo
fole	fotã	fólimo	fotijica	fóba	bile	vramale	respitale	cule
funil	funômo	futiname	fulha	futra	crepanil	chusatinil	tanil	ronil
prisma	pristabo	prisvamubo	prisfe	priste	bama	jonema	rairma	gusatima
broca	brolo	bróremos	brofe	bróvitara	janeka	trisca	lorka	respirica
castor	kastito	kasmol	casbomia	casbar	vretor	frotor	pelitator	raspetor
vitral	vilhe	virso	virestu	vilopatra	cotral	retral	fulitral	teripatral
harpa	ártina	harfu	harbo	árlogo	crimiapa	tripopa	respa	terpa
cuvete	culeto	cutijo	curoveli	curasteire	relite	lisabote	poimbrite	date
avental	atambos	acrelodi	abem	acandor	crismetal	testal	lopatal	mitaretal
tomada	tudarra	tolame	tutre	tupilano	plonida	retoda	benichoda	tiba
chaleira	xapecto	chatirpo	xate	chalipata	plora	teralhara	clebrera	bimplara
turbante	turvolrei	turpolha	turpimapa	turlo	coslente	procesite	binte	lubrite
regador	reputir	rebonja	retrelia	reba	fojador	lipodor	sador	febonidor

Target	First syllable primes				Last syllable primes			
ancinho	âncestina	andanfu	ampostea	anclar	tiponho	setinhu	penho	respalinhu
espaldar	estralhe	esgue	esfolta	esgrebinto	corredar	asplitedar	taledar	badar
espora	estano	esbino	estremife	estom	tonira	cafera	poira	flumangara
gárgola	gárfute	garle	gárqueja	garpilemo	resla	castila	frenebila	brokala
bomerangue	bugita	bupalhasse	bojão	bolinda	sanfingue	serriposgue	lasgue	hapegue
carrossel	cazapo	kalotapa	cafingues	cafa	rossacel	alhacel	resitassel	tissel
enchada	entrame	empuspo	entolina	embas	prisdada	vaiticida	ontenda	gueda
beliche	bepaneja	betro	belanta	bessanto	gomache	setaxe	lorxe	pinotache
cabide	kalemio	catino	cajo	kaponga	libode	bonade	putaride	pilde
pódio	pofia	pógista	polijada	pógue	lúdio	serapiu	kerapo	xastu
paleta	pachega	palipo	pafe	palinogo	grebinota	dufita	losta	ripota
biombo	binas	bitejona	bilame	bidera	fuganebu	dastebu	manabo	kibo
hélice	hécreco	ectra	hécopo	édiefe	rosace	lisse	queropace	potasse
molheira	muveta	muga	motrante	molimate	liponera	casira	xinica	festra
cavalo	kabima	cajusitas	kalupi	canha	gostalu	bratinalu	namobo	luslo
grelhador	greviuto	grechanho	grefuta	gredim	figresador	drudidor	guldor	haspodor
tiara	tinaman	titeba	tilusina	tirão	asepira	xaspira	brara	isera
bisturi	bislipu	bistonte	biscalia	bisgo	raspiri	tixo	prulori	cuitari
bigorna	bipenos	bivro	binaste	bimálio	santosna	fruna	gaudina	lariena
batina	babeluche	banuma	balupa	bachas	tonina	garupana	xesna	lolina
estribo	estitente	esnoca	esplota	esfrul	garetibu	manibo	numbo	nanhobu
esquadro	esfrine	eslonji	esno	eslasecre	lhadro	xusipedro	prulidro	kalandro
batuta	banuto	banur	bavação	barubamo	nureta	matinta	carto	benisota
ábaco	ágolo	hate	ásota	átirea	mincu	belenko	olimpaco	terecu
cafeteira	calázio	cabaçu	kalhe	catebezão	sozira	troninara	xoulipara	nira
espremedor	esfruni	escamoure	estakenhe	estês	passepador	flogueidor	avulador	jandor
galheteiro	gabimobas	gague	gachespiro	gafitão	carairo	aspefero	seru	oliraru
xilofone	xitofano	xitranfo	chibom	chicenita	estimane	judine	calne	patilane
ampulheta	anfunhale	amblutace	anque	ânchosca	espanfuta	colugita	colta	chetita

Target	First syllable primes				Last syllable primes			
castanholas	casmista	casmurreiro	casbuniro	casfim	acamélas	chebinolas	pafilas	clulas
beringela	bepiração	betoro	bejorinas	benho	atabeila	jenefala	esquela	hila
malagueta	mamenta	maprobante	maguim	manhocada	tireta	pimboleta	crata	frenebuta
abacate	afasbola	ateta	achaneto	assus	cherminte	kinutonte	ecotate	guete
pandeireta	panchestia	pampona	pambosito	panso	xalupata	apazita	chatenta	rinta
dobradiça	dufestim	dugues	dotília	doleciman	aquestiça	gustaressa	noiça	pumbaça
metrónomo	metinsaro	mechiene	megunto	mecam	lupomu	lascifimo	xintófamo	hámu
origami	otarris	ofilhetim	ovidendo	ofta	hanetimi	enchanti	carutimi	pomi
violino	vimeventa	virogoso	vilusto	vitas	crepuno	gosnu	invesgrano	estelinu
acordeão	amolfeda	afinfale	apormol	acum	consilião	lemaceão	bameão	elão
saxofone	saricano	sácuto	sáquesito	sáta	tefolene	barancone	balzasne	cróne
harmónica	harponião	harfimbo	harmos	hartobio	sandraka	barbeleca	alizaca	neka
manivela	mafinesta	maculobos	magota	malim	fivestela	saudocala	vaterla	lasla
catapulta	cafuneba	caplumo	canhobito	cate	lobismata	xincobita	agueta	herta
cavalete	kafatado	catrolita	kamerdo	caquil	latechote	husate	nosicite	moste
alicate	atufador	aglas	agróvio	abema	ciste	echante	gominote	crosimete
camaleão	capesteme	kafulha	kataurio	catre	judiscrião	suspião	saxoteão	treão
canivete	capustola	catapora	cafon	cabenha	pacombite	verrestute	blinte	falete
interruptor	intafecção	impanio	ingal	imblocar	grutor	chambatitor	carrancator	extector
megafone	medinadre	melingá	menistação	mefal	lingorine	falantrone	dobrene	mane
guilhotina	guigras	guinetesno	guisantres	guidameno	clomidina	menilana	fantona	brina
monociclo	moquetino	molambena	mócate	móba	teribaclu	bicutoclu	kateclo	puclo
espátula	esnafipre	estaglite	esfojo	esgam	plantila	verila	latagela	sasla
estirador	esprumano	esfulgar	esgorrala	esgal	croussador	posdor	locunedor	banamedor
grafonola	gramefati	granuguena	grabução	gralo	chapatela	sipatila	tremala	joula
cofre	konha	cobão	kolemapa	cóvesta	chafre	lifre	nonhafre	limatofre
trenó	trefu	trelhe	tregana	trebilado	chanó	leinó	felimano	guetano
leque	levim	lebão	lemona	lenhuneca	xuque	faque	gunaque	dufelique
guizo	guifui	guites	guinhates	guitrandesa	chuso	vertidaso	hulzo	jaquezo

Target	First syllable primes				Last syllable primes			
farol	fafo	faver	fadunga	fatrepina	gurol	lerol	lumirol	dantumarol
pavão	pacham	pafro	paratura	panhute	guvão	drevão	jaquevão	kilomivão
bule	bucho	bunha	bufeta	bulafano	deile	voule	satile	suspidale
selim	sevão	cefor	semanda	cetulimo	fulim	balim	garulim	poguetalim
queque	quela	quepo	queguna	quelopama	guque	treque	protaque	nalhenique
baton	bafui	bamão	bapona	banholada	guetom	chaton	paletom	gafenaton
brinco	brimpa	bringue	brinlano	brimbatana	fuco	naucu	lonico	hastudacu
chuteiras	chufada	xudamo	chunha	chugadeino	fluneiras	meirraras	bruras	hastiporas
adufe	afunto	aguesta	anhemula	abão	grofe	lerafe	gustofe	fetunafe
extintor	expimpo	extrufe	extre	expolisbo	dafutor	kalemator	bunitor	pantor
furador	fotisga	funhada	fulem	focamete	maledor	brapodor	klidor	linfraledor
andarilho	ânfagulha	andiessa	ampul	angusta	fulho	naguetolho	lambitalho	guestilho
transferidor	transguefa	transpotrame	translevina	transte	telefador	palafador	guetador	lerdor

APPENDIX C

European Portuguese target words and syllabic pseudohomophones for bilingual TOT study

Target	First syllable primes				Last syllable primes			
manga	manfesta	mambobos	mante	mampo	pachega	fouga	aliga	trega
panda	pancheste	pampono	pambos	panso	fetuda	jolida	tusda	ploda
pinguim	pintro	pimpota	pimbuno	pinco	caguim	triguim	taboguim	selaguim
tampão	tanguefa	tambotra	tanca	tandor	coupão	chapão	prulapão	trilupão
tigre	tinamão	titeba	tilus	tirão	sougre	rangre	capogre	palugre
tractor	trafate	travelo	traxo	trafe	vretor	frotor	pelitor	raspetôr
zebra	zefor	zelame	zêjos	zepador	tonibra	cafibra	pobra	gabra
balão	babeche	banuma	bapa	bachas	judislão	suslão	saxolão	trelão
cacto	capusto	cador	cafão	cabenha	paconto	verrestu	blinto	leto
canhão	cateme	kafulha	karriu	catre	junhão	susinhão	saxenhão	trenhão
dragão	dratina	drafor	drabé	dralógo	crimigão	tripogão	risgão	tergão
funil	fupômo	futime	fulha	futra	crepanil	chusanil	tanil	ronil
kiwi	quimamba	kirapo	kité	quibo	guvi	lawi	patuvi	chaléwi
prisma	pristabo	prisvamu	prisfe	priste	bama	jonema	raima	gusama
melão	melor	meremos	mefe	metara	trapilão	crugelão	tralão	bulão
cantil	campipu	cantonte	cambia	cango	raspitil	titil	pulotil	cretil
ostra	osnuto	hosnur	osvação	hosmo	nuretra	matintra	catra	sotra
pódio	pófia	pógita	polige	pogue	lúdio	seradiu	keradio	xasdio
banjo	bambas	bantona	banlame	bandir	ganeju	dasteiju	najo	kijo
chita	chigue	chilipo	xife	xigo	binota	dufeta	losta	rista
caixão	cainas	kaiveria	cairone	kaipo	trechão	tixão	conechão	poxão
pinça	pindufes	pingro	pimbu	pimpor	questiça	taressa	noiça	pumbaça
régua	rébulha	ressa	rectramo	rélvola	fugua	tragua	teligua	pitugua
pavão	pachalei	pafro	paratur	panho	guvão	drevão	cajevão	lomivão
balde	balcho	balna	balfeta	balfano	deide	voude	satide	pidade
batom	bafui	bamão	bapona	banhola	guetom	chiton	paletom	naston
brincos	brimpa	bringue	brinlano	brimbata	fucos	naucus	lonicos	hastucus
colchão	colpa	kolme	kolpima	colvato	guchão	trexão	protachão	nanixão
dedal	derra	devom	deterar	demarse	trodal	ridal	tenidal	cramadal

Target	First syllable primes				Last syllable primes			
farol	fafo	faver	fadunga	fapina	gurol	lerol	lumirol	danturol
fisga	fistile	fispada	fislem	fiscame	malega	brapoga	kliga	linga
luvas	lupimpo	lutrufe	lutre	lubo	dafovas	kalevas	buivas	pavas
íman	ifunto	iguesta	himu	hibão	creman	posman	patoman	crupaman
boina	boico	boipotim	boime	boiveto	mepina	cronina	sasna	quena
fada	fanona	fagortir	fasis	fapo	sisda	tospeda	crolida	penida
castor	kaspito	kasmol	casboia	casbar	vretor	frotor	litator	raspetor
pilão	pimano	pinenho	pido	pifru	chipolão	nenhilão	nelão	fralão
tripé	tripostar	triminos	tribão	trite	cranepé	nospé	lamapé	respé
couve	coutã	coulimo	côjica	couba	bive	pramave	respive	tuve
alga	altambos	alpelo	albem	aldor	crismega	tesga	lopaga	teiga
triciclo	triponga	trimaile	trifão	tripum	gultaclu	fameclo	vusclu	roclo
canguru	canfita	campasse	canjão	camba	pitaro	tempuru	cliro	floru
cilindro	citofa	sitranfo	sibom	cita	estadro	judidro	caldro	padro
coala	comana	cugusto	kolim	kugra	fetula	jodila	pola	prela
trampolim	tranva	tranfor	trambanda	transimo	felim	balim	garulim	guetalim
gorila	gomefa	gonugue	gução	gulo	patela	situla	terla	joula
hiena	itapum	hilostil	hivil	ibor	crena	posna	tripana	crupana
flamingo	flabima	flasitas	flapi	flanha	gostagu	bratingu	mogo	lusgo
ábaco	ágola	hate	ásota	hatir	mincu	belenko	límpico	tercu
papaia	pachega	palipo	pafe	pagro	grebinia	dufitia	lostia	riptia
gôndola	gontista	gombeiro	gombro	gonfim	camerla	pafila	flela	clula
pijama	pitrala	pimubo	pifres	pitol	crima	joteima	rirma	magusma
vampiro	vambobas	vangale	vanches	vambão	cararo	pefero	seru	rasru
brócolos	brólita	brótino	broque	brofo	rinelos	vonilus	calus	silos
dominó	dóveta	dóluso	dolus	dotas	crepunó	gusnó	tegranó	linó
lasanha	labule	lacantel	labar	lafa	muquinha	pitonha	monha	crunha
biquini	bilepu	bitonte	bicle	bigou	rasponi	troni	pruloni	culni
mosquito	musta	mustro	mosbalu	mustade	binto	queratu	telheto	dastu

Target	First syllable primes				Last syllable primes			
antena	anfunha	amblute	anque	ânchos	panfuna	lugina	colna	chena
búfalo	bucho	bunha	búceta	búcale	deilo	voulo	satilo	suspilo
morango	moquetim	mulambe	muca	mobão	ribago	bicogu	kalgo	pugo
pepino	pegulha	pedessa	pebal	pegão	funo	guenu	lambinu	guestino
varanda	valazo	vabaço	valhé	vacão	sozida	tronida	xouda	nida
girassol	gifui	gites	ginhates	gitrandes	chussol	tidassol	hulsol	jaqueçol
lareira	latano	labino	latre	latom	tonira	cafera	poira	flura
ananás	abosta	hacrelo	ablo	hacar	crismenás	tesnaz	lopinaz	mitenás
canela	karação	catoro	cajo	kanho	tabeila	nefala	erla	hila
toalha	tofar	tunol	tumeijo	togrepão	prilha	paselha	furpolha	sulha
toureiro	touvore	toupolha	tôpa	toulo	coslero	proceru	baro	cliru
salsichas	salfada	saldamo	saltra	salpar	flunechas	merraxas	bluxas	hachas
hélice	hécreco	ectra	écopo	héda	rosace	lisse	querosse	tace
avelã	afasbo	hateta	hachão	hasisus	chermilã	quitolam	coilã	guelam
cascata	cascebo	kaspona	casbos	kasbo	lupata	pazita	chenta	rinta
castiçal	kaspapo	casbone	casgues	kasfa	rossaçal	alhassal	tassal	praçal
alecrim	afunha	habluta	haque	achos	espacrim	colucrim	colcrim	checrim
amora	aponião	hafimbo	hamos	abio	sandara	barbera	uira	nera
grelhador	grevuto	grechanho	grefo	gredim	fisador	drudidor	guldor	hasdor
colibri	copampu	kotonte	kolia	cogo	raspobri	tobri	pulobri	labri
furacão	futeme	folhate	futa	fobol	judiscão	suspicão	tecão	crecão
medusa	menadre	melinga	menis	mefal	goriza	falasa	breza	masa

APPENDIX D

English target words and syllabic pseudohomophones for bilingual TOT study

Target	First syllable primes				Last syllable primes			
mango	manky	manka	manguitar	mankable	pargow	zego	flacurgow	flarargo
panda	panno	panson	pancerry	pantaver	dirda	milde	routerda	stabilde
penguin	pencoan	pencien	pencofle	penpocle	cagwin	fluguin	flotergwin	ranwoguin
tampon	tambin	tammen	tammolits	tamtlepe	limpen	fimpon	countepen	fluperpon
tiger	tibur	taible	tyeto	taicycra	strabger	clogar	civinger	cedintgar
tractor	traccar	tracler	tracliback	trackborder	crilter	flictor	pirdinter	runbostor
zebra	zeaclo	zeplo	zeecata	zetenat	trawbra	stibre	sticybra	patabre
balloon	bateas	bewoad	bapalog	bemando	diloon	culoen	ranroloon	sistaloen
cactus	caccor	cacket	kackate	cacdoli	bectus	bautas	tyetus	biwitas
cannon	kantin	candan	kansari	candlecroys	ballan	clayon	dalion	plurian
dragon	dragbash	dragcean	dragmisco	dragmoter	banon	clian	flacaren	tapheson
funnel	funtil	fundet	fundeta	funtlecer	tesel	beckil	flamesel	selsacil
kiwi	keehu	keaza	kealowfle	keebelto	codwi	cewy	bealowy	pansowi
prism	pritle	prifon	primaton	pripanto	clorasm	flobism	stammolesm	chammolasm
melon	melfur	meller	melnofla	mellinba	sopon	rufen	tysiun	datipon
canteen	kandoon	candion	kandlebreds	canderry	citteen	flocktean	bandrotein	unploteen
oyster	oisming	oyslum	oyscandle	oispabor	urtar	uncter	clofatir	sunpeter
podium	potens	powple	powshito	potenat	saydium	tradiom	bashmeadium	baleediom
banjo	banza	bansu	banlumming	banbluter	kijo	carjow	teajo	tonlijow
cheetah	cheetif	cheatab	cheecygra	sheabeddle	shactah	funta	janatah	nendota
coffin	cobid	codid	conata	coberdew	stacefin	banfin	cincafin	fillofin
tweezers	twealefs	twieclam	tweadorfus	tweelibor	phoozers	smouzars	cedinzers	bropazars
ruler	rugon	roobac	roopina	rucerry	dusler	muplar	stacedler	sasonlar
peacock	peasard	peetau	peaslamming	peebrali	riccock	beshcoc	barcecoc	pritlecock
bucket	buctus	bucloan	buckapser	buctory	boshet	pestat	tarcutet	stacilat
lipstick	lipprir	lipshir	lyptoli	lippatle	fimstick	cramstyk	unflostick	brocastick
earrings	earrates	eerred	eartofle	eershiva	blurings	oinrings	tesporings	bluterrings
mattress	mattet	matloff	mattinu	mattenfi	eagress	himrus	kenfaress	ayarus

Target	First syllable primes				Last syllable primes			
thimble	thimbroke	thimcle	thimfamid	thimborter	glubel	wrabble	hasable	pursasbel
lighthouse	lightcound	laitcrob	lightappla	lightcyble	crouhouse	bluhouse	troberhouse	floderhouse
slingshot	slincor	slingboom	slingonprit	slingtrople	drireshot	drillshot	tapheshot	artanshot
mittens	mitbe	myttyale	mitwilo	myttofle	rafens	pobans	calleinuns	probotens
magnet	maggel	magbom	maggalo	magsuner	padnet	raunut	stalenet	trabernut
beret	bebel	besel	berilo	berwony	fenrut	payret	kensarut	agaret
fairy	febor	feplace	fesadre	fedefle	triry	stenry	stribcerry	ruchtary
beaver	beebit	beasel	beabalo	beefani	coover	hivar	cedinver	cucolvar
pestle	peson	pesdor	pesabor	pesappa	puttle	mertle	fasaytle	masmertle
tripod	trily	trybid	trimygra	tryele	mudpod	pewpod	attenpod	lodapod
cabbage	cabtos	cablein	cabquito	cabbalo	bebage	tackage	candleage	lummingage
seaweed	seazood	seeban	seaquito	seebomes	roweed	joudwead	leizeweed	bolawead
tricycle	trysod	tritor	trirygra	trytopod	morcle	flaccle	hasacle	sunercle
kangaroo	candean	cantied	kanfaria	candinoun	pliroo	tunroe	mensaroe	ponniroo
cylinder	sibra	cywad	sirete	cyaras	lunder	boodar	cedidder	tedicdar
koala	koju	lowlin	cocapper	comajo	rolla	curla	vocolla	vapilla
trampoline	tramy	trambor	tramsticy	tramballied	callein	broleen	alnaline	stammoline
gorilla	gabar	gapon	goflacor	gaconcle	della	leala	nentola	varolla
hyena	hiber	hytle	hykevas	hyalu	sanna	calna	nendona	jaana
flamingo	flatour	flaright	flanesco	flacorli	bango	zego	pasago	melcurgo
abacus	hamick	ateck	adiup	asadre	seekas	pancus	tadrecus	blamiskas
papaya	paroute	pawon	panalog	pamarpin	quickya	trofya	barceya	clogteya
Gondola	gonnel	gonban	gonstecer	gonbartle	slayla	tusla	varalla	vavilla
pajamas	paleed	pasoud	panarop	pamelno	sarmus	shimas	myhumas	cinsamus
vampire	vampote	vambon	vampoli	vambussle	urter	stilir	sunfrecer	berular
broccoli	broughtfus	brodun	brofani	bronandle	shickli	calli	fluctoli	tyeli
domino	doran	dostick	docalla	dorate	marnow	borno	beddanow	sirquino
lasagna	lasight	laparc	lanarox	ladreeclape	ragna	broygna	kaagna	nundogna
bikini	bisite	bizeel	bihilo	bizito	banni	cunni	clictoni	durini

Target	First syllable primes				Last syllable primes			
mosquito	musmight	moswood	mostasor	moscatre	banto	bestow	potslito	biwitow
antenna	angoun	ansight	andeebrods	andole	marna	clona	allinna	vamilna
buffalo	buffold	buffle	buflizu	buffony	dringlo	weedlow	begnalo	birdalow
strawberry	strawgle	strawbod	strawmertin	strawbaddan	grary	flickry	berdory	rucktary
cucumber	kewbom	kewress	kewcopple	kewcipsod	boobar	liber	sungleber	stavelbar
balcony	balrun	baltus	ballumming	balspicon	spany	frainy	berpeany	strefcerny
sunflower	sunbon	sunnin	sunspecy	sunwraglard	fiher	phoozar	cucoper	starelar
fireplace	finy	filert	firaller	fitrackard	booplace	ceinplace	cucicplace	cutinplace
pineapple	pineam	pinedrex	pinemopon	pinehunnet	legle	ortle	puareple	stakelle
cinnamon	cinnin	cinspug	cinvamid	singrager	carmon	slayman	pluglemon	drobenman
tablecloth	tayron	tayfrea	tadreclyll	tayphegrorm	honcloth	cacloth	hennacloth	lomicloth
matador	macal	mavel	mapeob	mavatle	londor	drobdar	playdedar	callindor
sausages	sawdon	sawfur	sawrecle	sawlates	croges	spucges	selsecges	sticyges
propeller	proclig	pronet	proseges	profalnor	brober	drexar	stadecker	sunwracar
hazelnut	haypla	haybard	haysaspe	hayblebe	furtnut	hennut	meacacnut	babblenut
waterfall	wafrig	watow	wadlehork	wafflepurn	brocfall	plafall	fonnefall	bindafall
candlestick	cannoun	canbrit	canterhogs	canvafin	rilmstick	plaustick	cofrestick	printerstick
rosemary	rosespin	rowslet	rosekido	rowsvucter	prilry	certry	rumptary	scandcerry
blackberry	blackger	blackend	blactercle	blackinto	crocry	flugry	rurktary	strebcerry
barbecue	barback	barnoun	bargecov	barcecya	corcue	primkew	wablacue	sedlecue
hummingbird	hummo	hummle	humbican	humgibale	preabird	trubird	flutibird	clocktobird
hurricane	hurpro	hurgle	hurbary	hurpalum	crucane	plotcayn	fummicane	hessicayn
jellyfish	jelgo	jelfrop	jelmicall	jeldages	kifish	crobfish	copafish	flutifish